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Bechtel National, Inc.
San Francisco, CA

Prepared for

Industrial Environmental Research Lab.
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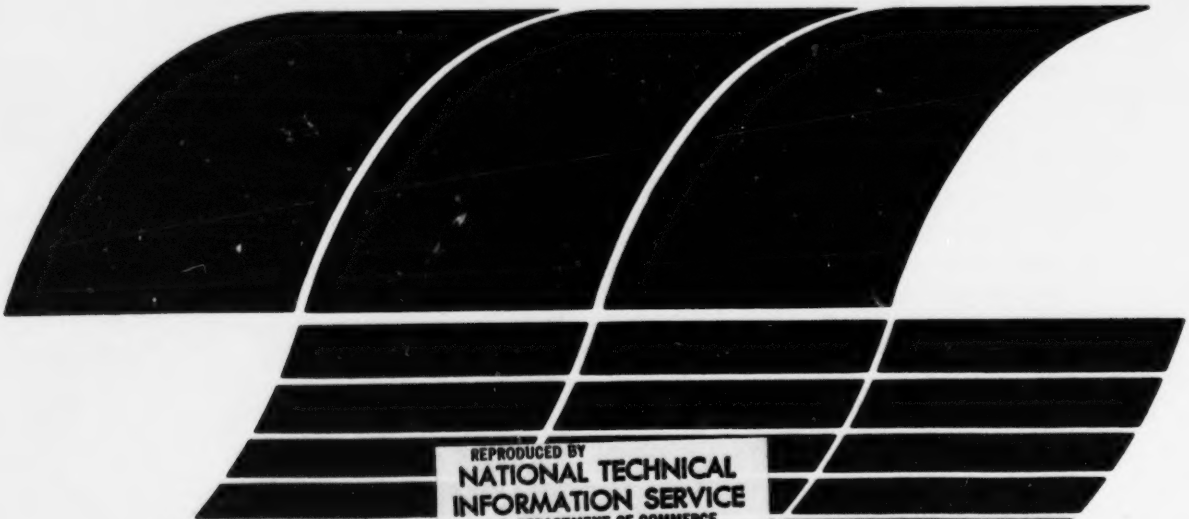

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16. ABSTRACT
The report summarizes results of advanced testing (from October 1974 through June 1978) of 30,000-35,000 acfm (10 MW equivalent) lime/limestone wet scrubbers for SO2 and particulate removal at TVA's Shawnee power station. Reliable scrubber and mist eliminator operations were demonstrated. It was shown that the mist eliminator is much easier to keep clean when the scrubber is operated under conditions giving high alkali utilization. Mathematical models were developed for predicting SO2 removal in limestone, lime, and magnesium-enhanced lime/limestone scrubbers. Forced oxidation with two scrubber loops was developed on the venturi/spray tower system with limestone, lime, and limestone/MgO slurry. Bleed stream oxidation was successful only with limestone/MgO slurry. Forced oxidation with a single scrubber loop was developed on the TCA system with limestone slurry. Other test blocks included limestone type and grind, automatic limestone feed control, Ceilcote egg-crate packing in the TCA, and flue gas emission characterization.

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Scrubbers	Aerosols	Alkali Scrubbing	07A, 13I	07D
Calcium Oxides	Mist	Particulate	07B	04B
Calcium Carbonates		Mist Eliminators		12A
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ABSTRACT

This final report presents the summary of test results from October 1974 through June 1978 of an Advanced Test Program on a prototype lime/limestone wet-scrubbing test facility for removing SO_2 and particulates from coal-fired boiler flue gases. The test facility is located at TVA's Shawnee Power Station, Paducah, Kentucky. Tests were conducted on two parallel scrubber systems, a venturi/spray tower (35,000 acfm @ 300°F) and a Turbulent Contact Absorber or TCA (30,000 acfm @ 300°F).

The initial phase of the test program was devoted to achieving reliable operation of the scrubber and, especially, the mist eliminator. In late 1975, when limestone utilization tests were being conducted, a significant breakthrough occurred when it was demonstrated repeatedly that the mist eliminator is much easier to keep clean when the scrubber is operated under conditions giving high alkali utilization.

High alkali utilization is inherent with a lime system. However, operation of a limestone system at high alkali utilization requires a reduction in limestone feed which causes a lowering of the pH and reduced SO_2 removal efficiency. This led to the investigation of chemical additives, such as magnesium oxide, to recover the lost SO_2 removal efficiency. Short-term (6 to 8 hours) factorial tests were then conducted to characterize the scrubber performance at different operating conditions, both with and without magnesium oxide addition. Mathematical models were fitted to the factorial test data, as well as longer-term (one week) test data, for predicting SO_2 removal as a function of operating parameters.

Beginning in January 1977, procedures for forced oxidation of the largely calcium sulfite slurries were investigated. Oxidized slurry solids, having much higher calcium sulfate (gypsum) content, have improved dewatering and handling characteristics.

Forced oxidation with two scrubber loops was developed on the venturi/spray tower system. This system was successfully demonstrated with limestone, lime, and limestone/MgO slurries. An open pipe air sparger discharging into an agitated tank was successfully used to oxidize the slurry. Attempts to oxidize the venturi/ spray tower bleed stream were successful only when magnesium ion was present to buffer the slurry pH and to increase the liquor sulfite concentration for oxidation. Forced oxidation with limestone slurry in a single scrubber loop was demonstrated on the TCA system. In this system, more efficient oxidation was achieved with an air sparger than with an eductor.

Other testing on the TCA included limestone type and grind testing, automatic limestone feed control testing, and limestone testing with Ceilcote egg-crate type packing. Flue gas characterization testing on both scrubber systems was conducted to determine inlet and outlet particulate mass loadings, particulate size distribution, and SO_3 concentration.

Auxiliary studies included laboratory reactivity studies of various limestone types and grinds, development of pressure drop correlations for both scrubbers, trace element analyses in the slurry liquor, and waste solids dewatering and characterization studies.

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TABLE OF CONTENTS

Notice ii
Abstract iii
Acknowledgments iv
Illustrations ix
Tables xii

Section Page

1 SUMMARY 1-1
2 INTRODUCTION 2-1
2.1 Test Facility 2-2
2.2 EPA Pilot Plant 2-4
2.3 Advanced Test Program 2-5
2.4 Reports 2-6
2.5 Definition of Terminology 2-10
3 LIME SCRUBBING 3-1
3.1 Chemistry of Lime Scrubbing 3-2
3.2 Factors Affecting Lime Scrubbing 3-7
3.3 Control of Lime Systems 3-13
4 LIMESTONE SCRUBBING 4-1
4.1 Chemistry of Limestone Scrubbing 4-2
4.2 Factors Affecting Limestone Scrubbing 4-5
4.3 Limestone Utilization as a Function of Scrubber Inlet pH 4-9
4.4 Limestone Type and Grind Test Results 4-19
4.5 Laboratory Limestone Reactivity Tests Results 4-22

Section Page

4.6 Automatic Limestone Feed Control 4-24

4.7 Control of Limestone Systems 4-25

5 LIME/LIMESTONE SCRUBBING WITH MAGNESIUM ENHANCEMENT 5-1

5.1 Effect of Magnesium Additive on Dissolved Sulfite Species 5-2

5.2 Importance of Calcium Solids Equilibria 5-3

5.3 Effectiveness of Magnesium in the Presense of Chloride 5-4

5.4 pH Independence of Dissolved Sulfite Concentrations 5-5

5.5 Lime/Limestone Tests with Magnesium Enhancement 5-9

6 FORCED OXIDATION 6-1

6.1 Forced Oxidation with Two Scrubber Loops on the Venturi/Spray Tower System 6-3

6.2 Forced Oxidation with One Scrubber Loop on the TCA System 6-18

6.3 Venturi/Spray Tower Bleed Stream Oxidation 6-34

7 MATHEMATICAL MODEL FOR SO_2 REMOVAL WITH CORRELATIONS OF SHAWNEE DATA 7-1

7.1 Development of the Model 7-3

7.2 Correlations of Shawnee Data for SO_2 Removal 7-7

7.3 Parametric Plots Derived from the Correlations 7-11

8 CALCULATIONS OF GYPSUM SATURATION 8-1

9 SCRUBBER CHARACTERISTICS 9-1

9.1 Turbulent Contact Absorber (TCA) 9-1

Section		Page
	9.2 Venturi	9-22
	9.3 Spray Tower	9-29
10	WATER BALANCES AROUND SCRUBBER SYSTEMS	10-1
	10.1 Factors Affecting Water Balances	10-1
	10.2 Limestone Systems with High Fly Ash Loading	10-6
	10.3 Lime Systems with High Fly Ash Loading	10-8
	10.4 Limestone and Lime Systems with Low Fly Ash Loading	10-9
	10.5 Summary	10-11
11	MIST ELIMINATOR SYSTEMS	11-1
	11.1 Description of Shawnee Mist Eliminators	11-3
	11.2 Other Mist Eliminator Configurations Tested at Shawnee	11-4
	11.3 Factors Influencing Clean Mist Eliminator Operation	11-6
	11.4 Operating Charateristics of Shawnee Mist Eliminator	11-13
12	OPERATING CONSIDERATIONS	12-1
	12.1 Hot Gas Cooling Interface	12-1
	12.2 Field Laboratory pH Measurement	12-2
	12.3 Reheat	12-4
13	EQUIPMENT OPERATING EXPERIENCE DURING LIME/LIMESTONE TESTING	13-1
	13.1 Scrubber Internals	13-1
	13.2 Oxidizers	13-7
	13.3 Reheaters	13-9
	13.4 Induced-Draft Fans	13-10

Section Page

13.5 Pumps 13-10
13.6 Alkali Addition Systems 13-12
13.7 Instrument Operating Experience 13-14
13.8 Other Materials and Equipment Evaluation 13-19

14 FLUE GAS CHARACTERIZATION FOR PARTICULATE AND SULFUR TRIOXIDE EMISSIONS 14-1
14.1 Particulate Mass Removal Efficiency 14-1
14.2 Particulate Size Distribution 14-3
14.3 Slurry Entrainment 14-5
14.4 Sulfuric Acid Vapor (SO_3) 14-6

15 WASTE SOLIDS DEWATERING AND HANDLING CHARACTERISTICS 15-1
15.1 Clarifiers 15-1
15.2 Filters 15-2
15.3 Centrifuge 15-3
15.4 Effects of Operating Conditions on Dewatering 15-4

16 ANALYTICAL REQUIREMENTS 16-1
16.1 General Test Schedule 16-1
16.2 Laboratory Staffing 16-3
16.3 Quality Assurance 16-3

17 REFERENCES 17-1

APPENDICES

A CONVERTING UNITS OF MEASURE A-1
B DATABASE SUMMARY B-1

ILLUSTRATIONS

Figure		Page
2-1	Schedule for Advanced Test Program	2-7
4-1	Stoichiometric Ratio Versus Scrubber Inlet Liquor pH in the Venturi/Spray Tower System With a Single Hold Tank at 20 Minutes Residence Time	4-10
4-2	Stoichiometric Ratio Versus Scrubber Inlet Slurry pH in the Venturi/Spray Tower System With a Single Hold Tank at 12 Minutes Residence Time	4-11
4-3	Stoichiometric Ratio Versus Scrubber Inlet Liquor pH in the Venturi/Spray Tower System With a Single Hold Tank at 6 Minutes Residence Time	4-12
4-4	The Effect of Effluent Hold Tank Residence Time and Scrubber Inlet Liquor pH on Stoichiometric Ratio in the Venturi/Spray Tower System	4-14
4-5	Stoichiometric Ratio Versus Scrubber Inlet Liquor pH in the TCA System With a Single Hold Tank at 12 Minutes Residence Time	4-15
4-6	Stoichiometric Ratio Versus Scrubber Inlet Liquor pH in the TCA System With Three Hold Tanks in Series at 14.4 Minutes Residence Time	4-16
4-7	Stoichiometric Ratio Versus Scrubber Inlet Liquor pH in the TCA System With Three Hold Tanks in Series at 10.8 Minutes Residence Time	4-17
4-8	The Effect of Scrubber Inlet Liquor pH and Hold Tank Configuration on Stoichiometric Ratio in the TCA System	4-18
5-1	Concentration of Dissolved Sulfite Species ($SO_3^=$, Mg_3^0, and $CaSO_3^0$) as a Function of Effective Magnesium Concentration (Mg - Cl/2)	5-6
5-2	Independence of Dissolved Sulfite Concentration ($SO_3^=$, Mg_3^0, and Ca_3^0) and Liquor pH at Various Concentrations of Effective Magnesium (Mg-Cl/2)	5-7
6-1	Flow Diagram for Two-Scrubber-Loop Forced-Oxidation Tests in the Venturi/Spray Tower System	6-4
6-2	Arrangement of the Venturi/Spray Tower Oxidation Tank With Sparger	6-5

Page

Figure

6-3 Flow Diagram for One-Scrubber-Loop Forced Oxidation With Air Eductor in the TCA System Using One Tank 6-21

6-4 Flow Diagram for One-Scrubber-Loop Forced Oxidation With Air Eductor in the TCA System Using Two Tanks 6-22

6-5 Arrangement of the TCA Oxidation Tank With Eductor in Vertical Position 6-24

6-6 Flow Diagram for One-Scrubber-Loop Forced Oxidation With Air Sparger in the TCA System Using One Tank 6-28

6-7 Flow Diagram for One-Scrubber-Loop Oxidation With Air Sparger in the TCA System Using Two Tanks 6-30

6-8 Arrangement of the TCA Oxidation Tank With Air Sparger 6-31

6-9 Flow Diagram for Bleed Stream Oxidation in the Venturi/ Spray Tower System 6-35

7-1 Predicted (Equation 7-7) Versus Measured SO_2 Removal - TCA With Limestone 7-9

7-2 Predicted (Equation 7-7) SO_2 Removal as a Function of Slurry Flow Rate and Total Height of Spheres - TCA With Limestone 7-12

7-3 Predicted (Equation 7-7) SO_2 Removal as a Function of Scrubber Inlet Liquor pH and Slurry Flow Rate - TCA With Limestone 7-13

7-4 Predicted (Equation 7-7) SO_2 Removal as a Function of Effective Liquor Magnesium Concentration and Slurry Flow Rate - TCA With Limestone 7-14

7-5 Predicted (Equation 7-7) SO_2 Removal as a Function of Liquid-to-Gas Ratio and Scrubber Inlet Liquor pH - Spray Tower With Limestone 7-15

7-6 Predicted (Equation 7-7) SO_2 Removal as a Function of Effective Liquor Magnesium Concentration and Liquid-to-Gas Ratio - Spray Tower With Limestone 7-16

7-7 Predicted (Equation 7-7) SO_2 Removal as a Function of Scrubber Inlet Liquor pH and Slurry Flow Rate - TCA With Lime 7-17

7-8 Predicted SO_2 Removal as a Function of Slurry Flow Rate and Effective Liquor Magnesium Concentration - TCA With Lime 7-18

Figure		Page
7-9	Predicted (Equation 7-7) SO_2 Removal as a Function of Scrubber Inlet Liquor pH and Liquid-to-Gas Ratio - Spray Tower With Lime	7-19
9-1	Schematic of Three-Bed TCA	9-2
9-2	Test Facility Mist Eliminator Configuration	9-3
9-3	TCA Bed Pressure Drop (3 Beds, 4 Grids) - 0 Inches Total Bed Height of Nitrile Foam Spheres	9-5
9-4	TCA Bed Pressure Drop (3 Beds, 4 Grids) - 15 Inches Total Bed Height of Nitrile Foam Spheres	9-6
9-5	TCA Bed Pressure Drop (3 Beds, 4 Grids) - 22.5 Inches Total Bed Height of Nitrile Foam Spheres	9-7
9-6	TCA Bed Pressure Drop (3 Beds, 4 Grids) - 30 Inches Total Bed Height of Nitrile Foam Spheres	9-8
9-7	Comparison of Experimental Data and Predicted Values of Bed Pressure Drop - Three-Stage TCA With 1-5/8 Inch Dia., 6.5 gram Solid Nitrile Foam Spheres	9-11
9-8	Comparison of Experimental Data and Predicted Values of Bed Pressure Drop - Three-Stage TCA Without Spheres	9-12
9-9	Failure Rate of 6-Gram TPR Spheres in Limestone/Fly Ash Slurry Service	9-15
9-10	Erosion/Shrinkage Rate of Nitrile Foam Spheres	9-17
9-11	Pressure Drop Across 4 Bar Grids and 23 Layers of Ceilcote Support Plate Packing	9-19
9-12	Schematic of Venturi Scrubber and Spray Tower	9-24
9-13	Comparison of Experimental Data and Predicted Values of Pressure Drop in the Chemico Venturi from Equation 9-3	9-26
9-14	Comparison of Experimental Data and Predicted Values of Pressure Drop in the Chemico Venturi from Equation 9-4	9-27
9-15	The Effect of Gas Velocity and Slurry Flow Rate on the Flue Gas Pressure Drop Across the Four Slurry Headers in the Spray Tower	9-31
9-16	The Effect of Header Position and Number of Headers on the Flue Gas Pressure Drop at 14 gpm/ft^2 Total Slurry Flow Rate	9-32

TABLES

Table		Page
1-1	Test Blocks on the Venturi/Spray Tower System During the Advanced Test Program	1-5
1-2	Test Blocks on the TCA System During the Advanced Test Program	1-6
3-1	Major Chemical Reactions in Lime Scrubbing of SO_2	3-3
4-1	Major Chemical Reactions Involved in Limestone Scrubbing of SO_2	4-3
4-2	Analyses of Limestones Used in the Test Series	4-20
4-3	Summary of TCA Limestone Type and Grind Tests (With high fly ash loading, no MgO addition)	4-21
4-4	Limestones Used in Reactivity Tests	4-23
5-1	Summary of Limestone Tests With MgO Addition on the TCA System	5-11
5-2	Summary of Lime Tests With MgO Addition on the TCA System	5-13
6-1	Results of Forced-Oxidation Tests With Two Scrubber Loops on the Venturi/Spray Tower System Using Limestone Slurry	6-7
6-2	Results of Forced-Oxidation Tests With Two Scrubber Loops on the Venturi/Spray Tower System Using Limestone Slurry With Added Magnesium Oxide	6-12
6-3	Results of Two-Scrubber-Loop Forced-Oxidation Lime Tests on the Venturi/Spray Tower System	6-15
6-4	Summary of One-Scrubber-Loop Forced-Oxidation Limestone Tests With Air Eductor on the TCA System	6-25
6-5	Summary of One-Scrubber-Loop Forced-Oxidation Limestone Tests With Air Sparger on the TCA System	6-33
6-6	Results of Forced-Oxidation Tests on the Venturi/Spray Tower Bleed Stream Using Limestone Slurry With Added Magnesium Oxide	6-37
7-1	Correlation for Predictions of SO_2 Removal by Limestone/Lime Wet Scrubbing With a Spray Tower or a TCA	7-10

Table		Page
10-1	Summary of Water Balances for Limestone Runs	10-3
10-2	Summary of Water Balances for Lime Runs	10-4
10-3	Water Balances for Runs With High and Low Fly Ash Loading With Forced Oxidation and Two-Stage Dewatering	10-5
11-1	Mist Eliminator Wash Systems	11-10
15-1	Summary of Centrifuge Operation, Wear, and Repair	15-5
15-2	Summary of Dewatering Characteristics on Shawnee System Bleed	15-7
16-1	Type and Frequency of Sample Analysis	16-2

Section 1

SUMMARY

This is the final report on an Advanced Test Program under the sponsorship of the Environmental Protection Agency (EPA) to test prototype lime and limestone wet-scrubbing systems for removing sulfur dioxide (SO_2) and particulate matter from coal-fired boiler flue gases. This report covers the period from October 1974 through June 1978. The test facility is located at the Tennessee Valley Authority (TVA) Shawnee Steam Plant, Paducah, Kentucky. Bechtel National, Inc.* of San Francisco is the major contractor and test director, and TVA is the constructor and facility operator.

The original program at the Shawnee Test Facility began in March 1972, and lasted until October 1974. Results from this test period are presented in Reference 1. During the original program, in which Bechtel also served as the major contractor and test director and TVA as the constructor and facility operator, emphasis was placed on solving scaling and plugging problems of the scrubber and mist eliminator and on demonstrating reliable operation.

Detailed results of the Advanced Test Program from October 1974 through June 1978 have been documented in four progress reports (References 2,

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* Bechtel Corporation before January 1978.

3, 4, and 5). This final report summarizes only the major conclusions and recommendations based on the findings in this period. As such, the context of the report is more qualitative in nature. Readers who are interested in more in-depth quantitative discussions are referred to the above references.

There are two parallel scrubber systems operated during the Advanced Test Program:

- A venturi followed by a spray tower
- A Turbulent Contact Absorber (TCA)

Each system has a capacity of approximately 10 MW equivalent in flue gas from Boiler No. 10 (35,000 acfm* @ 300°F for the venturi/spray tower and 30,000 acfm @ 300°F for the TCA). The flue gas contains 1500 to 4500 ppm of SO_2, and is withdrawn from the ductwork either upstream (high fly ash loading of 3 to 6 grains/dry scf) or downstream (low fly ash loading of 0.04 to 0.20 grain/dry scf) of the Boiler No. 10 particulate removal equipment.

In the early part of the Advanced Test Program (Reference 2), efforts on demonstrating reliable scrubber operation continued. The primary objective during that period was to achieve reliable operation of the mist eliminators.

A significant breakthrough occurred while the interrelationships among the operating pH, limestone utilization, hold tank design and residence time, and SO_2 removal were being investigated (Reference 3). It was demonstrated that reliable operation of the mist eliminator is a strong function of alkali utilization (i.e., clean mist eliminator operation is more easily maintained when the system is operated under conditions leading to high alkali utilization).

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* Although it is the policy of the EPA to use the metric system for quantitative descriptions, the British system is used in this report. Readers who are more accustomed to metric units are referred to the conversion table in Appendix A.

Fewer problems with mist eliminator fouling have been experienced with a lime system because of its inherent high alkali utilization, about 90 percent. However, operation of a limestone system at high utilization (above about 80 percent), to obtain reliable mist eliminator operation, results in a reduction of SO_2 removal efficiency due to the lower pH operating regime. This has been one of the major factors in redirecting the Shawnee program toward the investigation of chemical additives to overcome the loss of SO_2 removal.

In the latter part of the Advanced Test Program more emphasis was placed on the chemistry of lime and limestone scrubbing.

From February 1976 through November 1976 (Reference 4) extensive investigation was conducted on the magnesium-enhanced lime and limestone scrubbing systems. Addition of magnesium oxide (tested up to about 10,000 ppm effective Mg^{++} ion in liquor) increases the dissolved alkaline sulfite species ($SO_3^{=}$, $MgSO_3^{o}$, and $CaSO_3^{o}$) in liquor for SO_2 removal. Both short factorial tests (6 to 8 hours each) and longer term tests (1 week each) were conducted.

The major effort of testing in the period from November 1976 through June 1978 (Reference 5) was directed toward developing forced-oxidation procedures. Forced oxidation converts predominantly calcium sulfite sludge to calcium sulfate (gypsum). The latter has improved dewatering and handling characteristics. Calcium sulfite slurry settles slowly; the dewatered sludge has high water content (40 to 50 percent) and is thixotropic. Oxidized gypsum slurry settles much faster and dewaters easily to a moist soil-like mass (15 percent water) which is easy to handle.

Tables 1-1 and 1-2 list the test blocks conducted at Shawnee on the venturi/ spray tower and TCA, respectively. The test blocks are classified according to the type of alkali, fly ash loading in flue gas, MgO addition, and oxidation scheme (no forced oxidation, bleed stream oxidation, one or two-loop oxidation*). Other combinations of these variables are possible, but they are either of lesser interest or not practical. For example, a lime system with one-loop forced oxidation (high or low fly ash loading, and with or without MgO addition) is not expected to yield good SO_2 removal because of the oxidation of scrubbing sulfite species to non-scrubbing sulfate. Time limitations prevented investigation of other combinations. The specific objectives of the Advanced Test Program are delineated in Section 2.3.

A brief description of the chemistry of lime and limestone scrubbing is presented in Sections 3 and 4, along with a qualitative discussion of the effects of operating variables on reliable, scale-free scrubber operation. Major operating variables include pH, alkali utilization, slurry solids concentration, hold tank residence time and configuration, liquid-to-gas ratio, fly ash loading, chloride concentration, oxidation, and sulfite and sulfate saturations. System controls with respect to SO_2 removal performance and reliablility are also discussed. The relationship between pH and limestone utilization, and the limestone reactivity of different limestone types and grinds are given in Section 4.

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*See Section 2.5.10 for the definitions of one-loop and two-loop forced oxidation.

Table 1-1

TEST BLOCKS CONDUCTED ON THE VENTURI/SPRAY TOWER SYSTEM DURING THE ADVANCED TEST PROGRAM

Test Block	Alkali	Fly Ash Loading	MgO Addition	Oxidation Scheme(1)
1	Limestone	High	Yes	No
2	Limestone	High	Yes	Bleed Steam
3	Limestone	High	Yes	2-loop
4	Limestone	High	No	No
5(2)	Limestone	High	No	2-loop
6	Limestone	Low	No	No
7	Limestone	Low	No	2-loop
8	Lime	High	Yes	No
9(2)	Lime	High	No	No
10(2)	Lime	High	No	2-loop
11	Lime	Low	Yes	No
12	Lime	Low	No	No
13	Lime	Low	No	2-loop

---

(1) All oxidation tests used either an air sparger ring or a 3-inch air pipe.

(2) Includes long-term (greater than one month) reliability tests.

Table 1-2

TEST BLOCKS CONDUCTED ON THE TCA SYSTEM DURING THE ADVANCED TEST PROGRAM

Test Block	Alkali	Fly Ash Loading	MgO Addition	Oxidation Scheme
1	Limestone	High	Yes	No
2(1)	Limestone	High	Yes	1-loop, Air Sparger
3(2)	Limestone	High	No	No
4	Limestone	High	No	1-loop, Air Eductor
5	Limestone	High	No	1-loop, Air Sparger
6	Limestone	Low	No	No
7	Lime	High	Yes	No
8	Lime	High	No	No

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(1) One run only.

(2) Includes long-term (greater than one month) tests.

The effect of magnesium addition on SO_2 removal is presented in Section 5. Forced-oxidation procedures and test results are presented in Section 6. Mathematical models correlating Shawnee SO_2 removal data, with and without magnesium enhancement, are given in Section 7. Parametric plots of SO_2 removal as a function of operating variables are also shown.

Simplified equations for calculating gypsum saturation from the measured concentrations of calcium, magnesium, and sulfate ions are given in Section 8. The equations were fitted to the predicted values of gypsum saturation from the Bechtel-Modified Radian Equilibrium Computer Program (Reference 1). The equations are useful for those not having access to the modified Radian program.

Section 9 presents the mechanical operating characteristics of the TCA, venturi, and spray tower scrubbers. The pressure drop, turndown characteristics, and ranges of operating conditions are discussed.

Water balances around scrubber systems for closed-liquor-loop operation are given in Section 10. Makeup water requirements under a wide range of operating conditions are calculated based on the 10 MW size Shawnee high-sulfur scrubbers. The results should allow extrapolation to larger scale units operating under similar conditions.

Section 11 presents the mist eliminator operating experience at Shawnee. Alkali utilization was identified as the most important factor affecting the mist eliminator operability. It is much easier to keep the mist eliminator clean at high alkali utilization than at low utilization.

In Section 12 experiences with operating difficulties, and the appropriate steps taken to solve problems, are presented. These involved preventing solids and scale buildup at the hot-gas/cooling slurry interface in the TCA inlet duct, maintaining accurate pH measurements, and flue gas reheating.

Operating experience with equipment and materials during the Advanced Test Program are summarized in Section 13. Conclusions are given wherever possible.

A brief summary is given in Section 14 of the results of the stack gas emission characterization tests on both venturi/spray tower and TCA systems. Particulate mass removal efficiency, typical outlet mass loading, particulate size distribution, slurry entrainment, and sulfuric acid vapor (SO_3) emission are discussed.

Section 15 presents the operating experience with the dewatering equipment (clarifiers, filter, and centrifuge). Laboratory results on cylinder settling tests and vacuum funnel filtration tests, which are routinely conducted to monitor the slurry settling and dewatering characteristics, are also presented. Major factors affecting these properties are gypsum content in the sludge (oxidized or unoxidized), magnesium concentration in the liquor, and initial slurry solids concentration. The laboratory results correlated well with the results from the filter and centrifuge.

Finally, Section 16 presents the analytical requirements as practiced at Shawnee. The sample locations, type and frequency of analyses, and the criteria used to judge the acceptability of the analytical results are given. It should be noted that the Shawnee laboratory is fully equipped and staffed to perform all necessary chemical analyses, not only for process controls but also for characterizing the scrubber performances. Therefore, the Shawnee laboratory operation is elaborate by necessity for a research facility, and is not typical of a full scale flue gas desulfurization plant.

Section 2

INTRODUCTION

In June 1968 a program was initiated under the direction of the Environmental Protection Agency (EPA)* to test prototype lime and limestone wet-scrubbing systems for removing SO_2 and particulates from flue gases. A test facility was built which operates with flue gas from coal-fired Boiler No. 10 at the Tennessee Valley Authority (TVA) Shawnee Steam Plant, Paducah, Kentucky. Bechtel Corporation of San Francisco was the major contractor and test director, and TVA was the constructor and facility operator.

The original testing program at the facility lasted from March 1972 to October 1974. Results are presented in Reference 1. During the original program emphasis was placed on solving scaling and mist eliminator problems for demonstrating reliable operation.

In June 1974 the EPA, through its Office of Research and Development and Control Systems Laboratory, initiated an Advanced Test Program at the Shawnee Test Facility. Bechtel continued as the major contractor and test director, and TVA as the constructor and facility operator. During the Advanced Test Program more emphasis was placed on the chemistry of lime and limestone scrubbing. Four progress reports have been published (References 2, 3, 4, 5) which document the results of the Advanced Test Program from October 1974 through June 1978. This final report presents conclusions and recommendations based on the results of the Advanced Test Program.

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* The National Air Pollution Control Administration prior to 1970.

2.1 TEST FACILITY

Initially the Shawnee Test Facility included three parallel lime/limestone wet scrubbing systems, all operating on flue gas from Boiler No. 10 at the Shawnee Steam Plant. However, one system (Marble-Bed absorber) was discontinued early in the program because of operational difficulties. The two scrubbers in operation during the Advanced Test Program were:

- A venturi followed by a spray tower
- A Turbulent Contact Absorber (TCA)

These scrubbers were chosen for their ability to remove both SO_2 and particulates from the burning of medium- to high-sulfur coal. Each system has a capacity of approximately 10 MW equivalent in flue gas (35,000 acfm @ 300°F for the venturi/spray tower and 30,000 acfm @ 300°F for the TCA). The systems operate with flue gas containing 1500 to 4500 ppm of SO_2 obtained either upstream (3 to 6 grains/dry scf of particulates) or downstream (0.04 to 0.20 grain/dry scf of particulates) from Boiler No. 10 particulate removal equipment.

The venturi and spray tower can operate together with both scrubbers discharging into a common effluent hold tank, or alternatively, the system can operate as two independent scrubbing loops in series with each scrubber discharging into a separate hold tank. In the former case, forced oxidation of sulfite to sulfate was effected by sparging air into a bleed stream hold tank. In the latter case with two-scrubber-loop operation, air was introduced into the venturi hold tank which was normally followed by a small desupersaturation tank to provide additional time for gypsum crystallization and air-free pump suction.

The TCA system can operate with a single effluent hold tank or up to three tanks in series. Air for forced oxidation can be introduced into a hold tank within the scrubber loop.

Alkali is fed to the scrubber system as a slurry. Lime is slaked onsite to a 20 weight percent slurry with makeup water. Limestone is dry-ground onsite and slurried to a 60 weight percent slurry with makeup water or clarified liquor from the dewatering system. Scrubber additives such as magnesium oxide are metered as dry powder directly to the hold tanks.

Each scrubbing system has its own independent dewatering system. A tightly closed liquor loop is maintained with all liquor from the dewatering systems returned to the scrubbing loops. Water leaves the scrubbing system via the discharge solids and the humidified flue gas. A small amount of water also leaves the system with the flue gas as entrained liquid droplets. The venturi/ spray tower system normally operates with a thickener followed by a rotary drum vacuum filter. The TCA dewatering system normally consists of a thickener followed by a solid bowl centrifuge. Discharge solids concentrations normally range from about 50 weight percent for unoxidized solids to above 80 weight percent for oxidized solids.

The scrubbing systems are highly instrumented with continuous recording of important process variables, including flue gas flow rate, inlet and outlet SO_2 concentration, major slurry and liquor stream flow rates and densities, inlet and outlet slurry liquor pH, tank levels, oxidation air rates, and pressure drops across major pieces of equipment.

The onsite analytical laboratory, staffed around the clock, provides complete slurry analyses at least once a shift and runs supplemental analyses as needed.

The test facility has its own TVA operations, maintenance, laboratory, and technical staff, which are independent of the power plant operation. Bechtel maintains a small onsite staff to direct the program. In addition, Bechtel personnel in the San Francisco Home Office provide the technical support and direction; TVA's Emission Control Development Projects group at Muscle Shoals, Alabama, provides engineering support.

2.2 EPA PILOT PLANT

There are two smaller scrubbing systems (300 acfm or 0.1 MW equivalent each) at the EPA Industrial Environmental Research Laboratory (IERL) in Research Triangle Park, North Carolina. These small pilot-scale scrubber systems are capable of simulating the Shawnee scrubber systems with excellent agreement in the lime/limestone wet-scrubbing chemistry. Preliminary data are generated on the pilot-scale system to determine the validity of new process concepts and to guide the selection of those promising concepts that should logically be investigated on the larger scale Shawnee units. Examples of studies originating at the EPA pilot plant and then later investigated at the Shawnee test facility include gypsum unsaturated operation, increasing limestone utilization, forced oxidation of sulfite to sulfate, and magnesium-enhanced lime and limestone scrubbing.

2.3 ADVANCED TEST PROGRAM

This section contains a description of the Shawnee Advanced Test Program, which began in October 1974 and was completed in June 1978. The objectives of the Advanced Test Program were:

- To demonstrate process reliability, with an emphasis on mist elimination systems
- To investigate advanced process and equipment design variations for improving system reliability and economics
- To evaluate process variations for a substantial increase in alkali utilization for limestone systems
- To evaluate the effect of increased magnesium ion concentration on improving control, reducing gypsum saturation, and increasing SO_2 removal
- To evaluate the efficiency and reliability of lime and limestone scrubbers under conditions of widely varying flue gas flow rate and inlet SO_2 concentration
- To evaluate system performance and reliability without fly ash in the flue gas
- To determine the effectiveness of forced oxidation in producing an improved throwaway sludge product
- To determine the practical upper limits of SO_2 removal efficiency for both limestone and lime scrubbing systems
- To perform reliability demonstration runs on advanced process and equipment design variations
- To characterize stack gas emissions, including inlet and outlet particulate mass loading and size distribution, slurry entrainment and total sulfate emissions
- To evaluate methods of automatic control
- To provide material for the field evaluation of sludge disposal processes. (The field evaluation is being conducted under a separate EPA program.)

- To evaluate corrosion and wear of alternative plant equipment components and materials
- To develop a computer program for the design and cost comparison of full-scale lime and limestone systems

A bar chart of the Advanced Test Program, showing the time spent on each of the defined objectives, is presented in Figure 2-1.

2.4 REPORTS

This final report summarizes the recommendations and conclusions resulting from the Advanced Test Program. The tests conducted during the Advanced Test Program are documented in four earlier progress reports. This section lists these reports and briefly describes the content of each.

2.4.1 First Progress Report

The First Progress Report (Reference 2) presents the results of testing from October 1974 through mid-April 1975. During this period the primary objective was to achieve reliable operation of the mist eliminators. Reliable operation was demonstrated with lime slurry on the venturi spray tower system in an 823-hour run at 8 ft/sec superficial flue gas velocity. With limestone slurry, reliable operation was achieved through the use of a wash tray to isolate the mist eliminator from the scrubbing slurry. The TCA system was was operated successfully with such a wash tray in limestone service in an 1835-hour run*

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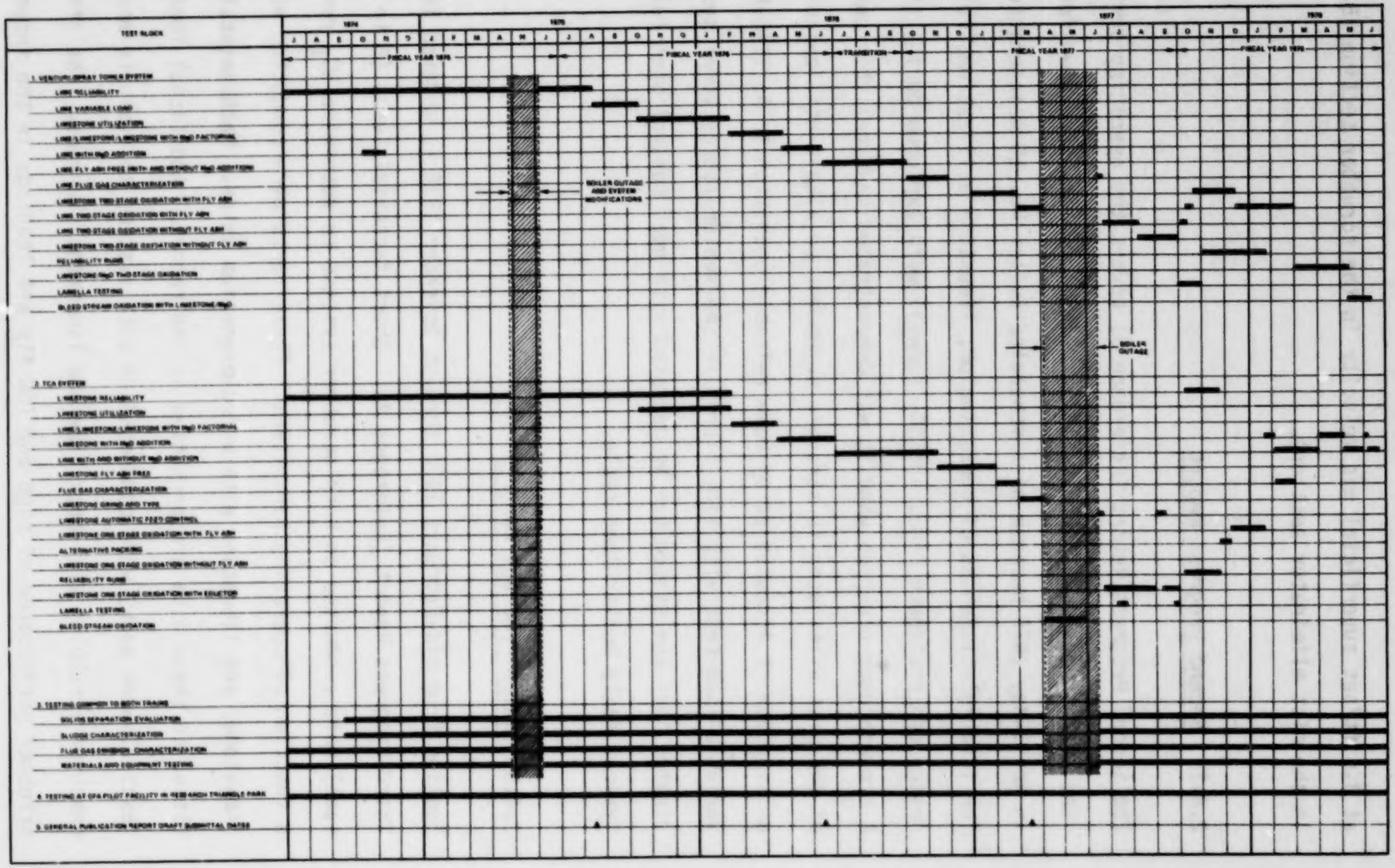
*The test, Run 535-2A, was made at an average limestone utilization of only 65 percent before it was discovered that high alkali utilization (greater than about 85 percent) promotes reliable mist eliminator operation (see Reference 3 and Section 11). Reliable mist eliminator operation has been achieved routinely in the later tests at high alkali utilization and 12.5 ft/sec scrubber superficial gas velocity using a 3-pass open-vane chevron mist eliminator without a wash tray (References 4 and 5).

Figure 2-1

Schedule For Advanced Test Program



at 8.6 ft/sec superficial gas velocity in the scrubber section (5.6 ft/sec in the mist eliminator section).

2.4.2 Second Progress Report

The Second Progress Report (Reference 3) covers the operating period from June 1975 through mid-February 1976. (The scrubbers were down for six weeks in April-May 1975 because of a scheduled Boiler No. 10 maintenance outage.) The interrelationships of operating pH, limestone utilization, hold tank design and residence time, and SO_2 removal were explored during this period. A breakthrough occurred when it was demonstrated that reliable operation of the mist eliminator is strongly dependent on alkali utilization. (High utilization is accompanied by more reliable operation.) An 1143-hour variable-load test with lime slurry in the venturi/spray tower system demonstrated that the system can be operated with good control when following a typical daily boiler load cycle.

2.4.3 Third Progress Report

Testing from mid-February 1976 through November 1976 is covered in the Third Progress Report (Reference 4). Short factorial tests (6 to 8 hours each) were conducted on both scrubber systems to determine SO_2 removal as a function of operating parameters. These tests were conducted with lime, limestone, and limestone with added magnesium oxide. Mathematical models fitted to these data are presented in the report. Additional longer term tests (1 week each) were conducted on both systems to evaluate magnesium enhanced scrubbing with both lime and limestone slurries. The effects on scrubber performance of high and low fly ash loadings in the incoming flue gas were also explored. In flue gas characterization studies, scrubber inlet and outlet particulate mass loading, particulate size distribution, and sulfuric acid mist (SO_3) concentration were measured as a function of operating conditions.

2.4.4 Fourth Progress Report

The Fourth Progress Report (Reference 5) documents testing from late-November 1976 through June 1978. The major emphasis during this period was on developing forced oxidation procedures to convert the predominantly calcium sulfite sludge to calcium sulfate (gypsum). Such oxidized slurry solids have improved dewatering and handling properties.

Further tests were conducted with low fly ash loadings and with added magnesium oxide. Additional testing included limestone type and grind testing, automatic limestone feed control testing, and limestone testing with Ceilcote egg-crate type packing. Monitoring of flue gas mass loading, particulate size distribution, and sulfuric acid mist continued.

Two additional limestone reliability tests were conducted: a 747-hour test on the TCA without forced oxidation and a 840-hour test on the venturi/spray tower in a two-scrubber-loop configuration with forced oxidation. A 779-hour lime reliability test was also conducted on the venturi/spray tower in a two-scrubber-loop configuration with forced oxidation.

Auxiliary studies during this test period included laboratory reactivity studies of various limestone types and grinds, development of pressure drop correlations for both scrubbers, trace element analyses in the slurry liquor, and waste solids dewatering and characterization studies.

2.4.5 Database

All major analytical data for the entire Advanced Test Program has been recorded in an active database along with test conditions for each run. A database report including test conditions and analytical summaries for each run is given in Appendix B.

2.4.6 Laboratory Procedures Manual

All analytical procedures used in the Shawnee onsite laboratory have been documented in a Laboratory Procedures Manual (Reference 6). A copy of this manual is available on request from the project manager, Bechtel National, Inc.

2.5 DEFINITION OF TERMINOLOGY

This subsection defines the terminology of lime/limestone wet scrubbing, as used in this report.

2.5.1 Air Stoichiometry

For a lime/limestone system using forced oxidation, the air stoichiometry is the number of gram-atoms of oxygen fed to the air sparger per gram-mole of SO_2 absorbed. One mole of sulfite or bisulfite ions ($SO_3^=$, HSO_3^-) requires one atom of oxygen to be oxidized to sulfate or bisulfate ($SO_4^=$, HSO_4^-). The calculated values for air stoichiometry would be higher if the moles of SO_2 oxidized naturally in the scrubber and hold tank are excluded from the moles of SO_2 absorbed.

2.5.2 Closed Liquor Loop

A scrubber system is said to operate with closed liquor loop when no excess liquor stream is discharged other than that associated with the waste sludge.

Closed loop operation requires either a solids dewatering device (clarifier, filter, centrifuge) or a pond, with recycle of all supernatant liquor to the scrubber system.

For Shawnee closed liquor loop operation, discharge of excess liquor, such as clarifier overflow or filtrate, is not allowed. When a clarifier alone is used, the system waste discharge (clarifier underflow) solids concentration is normally maintained at about 40 percent. With a filter or centrifuge in series with the clarifier, the waste discharge (filter or centrifuge cake) solids concentrations range from 50 to over 80 percent, increasing with increased gypsum content. Thus a very "tight" liquor loop is achieved with forced oxidation (high gypsum content in solids) and with filter or centrifuge as a final dewatering device.

Makeup water (mist eliminator wash, water in fresh alkali addition stream, and recirculated slurry pump seal water) is limited to the quantity which leaves the scrubber system with flue gas (as evaporated water and entrainment) and discharge sludge.

2.5.3 Effective Magnesium

Effective magnesium is total dissolved magnesium minus one-half the total dissolved chloride, in gram-moles/liter. Magnesium is added to a lime/limestone wet scrubbing system to enhance the SO_2 removal. Although dissolved magnesium sulfite/sulfate affects SO_2 removal, magnesium chloride ($MgCl_2$) has little effect.

2.5.4 Gas Velocity

Gas velocity is the velocity of humidified flue gas (125°F) through the scrubber, based upon empty scrubber cross-sectional area (no allowance made for piping, spray nozzles, or other scrubber internals).

2.5.5 Lime/Limestone Stoichiometry and Utilization

Lime/limestone stoichiometry is the ratio of the calcium added as lime or limestone to the SO_2 absorbed in the scrubber, mole/mole. Lime/limestone utilization, expressed in percent, is the inverse of stoichiometry, multiplied by 100 percent.

2.5.6 Liquid-to-Gas Ratio

The liquid-to-gas ratio, or L/G, is the gallons per minute of slurry recirculated to the scrubber divided by the thousands of cubic feet per minute of humidified gas (125°F) flowing through the scrubber.

2.5.7 Particulate Mass Loading

The particulate mass loading of the scrubber inlet or outlet gas is usually expressed as the total weight of solid particles (fly ash and solid reaction products) in grains per dry standard cubic foot of gas (60°F). Particulate emissions standards are usually specified in pounds of particulates in the stack gas per million Btu of boiler heat input. For a typical Shawnee coal and 30 percent total excess air (boiler excess air plus air in-leakage to system), an emission of 0.10 lb particulates/MM Btu is equivalent to a stack gas particulate mass loading of 0.052 gr/dry scf.

2.5.8 SO_2 Make-per-Pass

The SO_2 make-per-pass is defined as the number of milligram-moles of SO_2 absorbed in the scrubber per liter of liquor as the recirculated slurry makes one pass through the scrubber.

2.5.9 Statistical Parameters Used with Correlations

The accuracy of correlations of Shawnee data is usually expressed in terms of two statistical parameters: the standard error of estimate and the percent of variation in the data explained (sometimes called the index of determination).

The fraction of variation explained by a correlation is equal to R^2, where R is the correlation coefficient. The equation defining R^2 is:

$$\text{Fraction of Variation Explained} = R^2 = 1 - \frac{\Sigma(y-y')^2}{\Sigma(y-\bar{y})^2}$$

where:

y = value of the independent variable for a particular data point

y' = predicted (correlation) value of the independent variable for the same data point

$\bar{y}$ = arithmetic average of all values of the independent variable in the correlated set of data

The percent of variation is equal to 100 x R^2.

The standard error of estimate is defined by the following equation:

$$\text{Standard Error of Estimate} = \sqrt{\frac{\Sigma(y-y')^2}{n-k-1}}$$

where:

n = number of data points in the correlated set of data

k = number of dependent variables fitted with coefficients

For a normal distribution of errors, or deviations between the measured and predicted values of the independent variable, about two-thirds of the predicted values should be within plus/minus one standard error of the measured values, and about 95 percent within plus/minus two standard errors.

2.5.10 One-Loop/Two-Loop Forced Oxidation

Forced oxidation is achieved by air sparging of the slurry in an oxidation tank, to convert calcium sulfite solids ($CaSO_3 \cdot 1/2H_2O$) to gypsum ($CaSO_4 \cdot 2H_2O$).

For a one-loop forced oxidation system, the slurry effluents from all scrubbers in the system (e.g., venturi scrubber and spray tower at Shawnee constitute a two-scrubber system, and TCA a one-scrubber system) are sent to one tank, which is the oxidation tank. A one-loop system may or may not include a second hold tank for further alkali dissolution and gypsum crystallization prior to recycle to the scrubbers.

For a two-loop forced oxidation system, there are two scrubbers (e.g., venturi scrubber and spray tower at Shawnee) with each scrubber effluent going to a separate tank. The effluent hold tank for the upstream scrubber (in terms of gas flow) is the oxidation tank.

2.5.11 Gypsum Saturation in Liquor

The fraction gypsum saturation of a limestone/lime wet scrubbing liquor is defined as:

$$\text{Fraction Gypsum Saturation} = \frac{(Ca^{++})(SO_4^{=})}{K_{sp}}$$

where:

(Ca^{++}), $(SO_4^{=})$ = activities of dissolved Ca^{++} and $SO_4^{=}$ ions, respectively, g-mole/l.

K_{sp} = solubility product for gypsum

= 2.2×10^{-5} (g-mole/l)^2 at 50°C

Percent gypsum saturation is 100 percent times the fraction gypsum saturation. The fraction gypsum saturation of Shawnee scrubbing liquors are calculated by inputting the laboratory liquor analytical data into either the Bechtel-Modified Radian Equilibrium Computer Program (Reference 1) or the simplified equations presented in Section 8.

Section 3

LIME SCRUBBING

Quicklime (CaO) is produced from limestone ($CaCO_3$) by calcining to drive off CO_2. It is normally delivered to the site as pebbles and stored in silos. Lime is fed to the scrubbers in a 20 weight percent slurry after having been slaked (combined with water) to form hydrated lime [$Ca(OH)_2$]. As a scrubbing medium, lime has several advantages over limestone. Lime is more reactive than limestone and therefore a lime slurry scrubbing system is more responsive. Alkali utilization (moles SO_2 removed per mole of alkali) is usually better with lime. Furthermore, transportation costs are less per unit of alkalinity. The major drawback of lime is its higher cost at the point of origin.

In this section a simplified description of the chemistry of lime scrubbing is presented, followed by a discussion of operating conditions and control procedures.

The chemistry described was compiled from several sources and is not wholly based on results at the Shawnee Test Facility. Documentation of sources is given where possible. Details of the chemistry presented are based on interpretation of observations to date and are subject to modification as more information becomes available.

3.1 CHEMISTRY OF LIME SCRUBBING

The overall reaction of lime with SO_2 may be represented by:

$$CaO + SO_2 \longrightarrow CaSO_3 \qquad (3\text{-}1)$$

One mole of lime reacts with one mole of sulfur dioxide to produce one mole of calcium sulfite. The product is actually a mixture of calcium sulfite hemihydrate ($CaSO_3 \cdot 1/2\ H_2O$) and the oxidation product, calcium sulfate dihydrate ($CaSO_4 \cdot 2\ H_2O$), commonly called gypsum.

The detailed reaction mechanism of this process is complex, involving mass transfer between the gas, liquid, and solid phases, with several reactants in each phase (Reference 7). For this reason equations that describe the chemistry can be written in many ways, depending on which aspect of mass transfer is being emphasized. Moreover, scrubber operating conditions such as pH, liquid-to-gas ratio, and hold tank residence time can determine which reactions predominate, and whether they occur in the scrubber or in the hold tank (Reference 8).

A representative set of chemical equations that describe wet scrubbing of SO_2 by lime is shown in Table 3-1. They describe the main reactions in an SO_2 wet-scrubbing system using lime under the following normal operating conditions:

Recirculated slurry liquor pH	=	between 7 and 9 at the scrubber inlet and between 4.5 and 5.5 at the scrubber outlet
Stoichiometric ratio (moles of lime added per mole of SO_2 absorbed)	=	1.0 to 1.2

Table 3-1

MAJOR CHEMICAL REACTIONS IN LIME SCRUBBING OF SO_2

Reactions in the Scrubber

Absorption

SO_2 (gas) $\longrightarrow$ SO_2 (aqueous) (1)

Neutralization

$SO_3^{=} + SO_2 \text{ (aqueous)} + H_2O \longrightarrow 2\ HSO_3^{-}$ (2)

Dissolution

$CaSO_3 \text{ (solid)} \longrightarrow Ca^{++} + SO_3^{=}$ (3)

Oxidation

$HSO_3^{-} + 1/2\ O_2 \longrightarrow SO_4^{=} + H^{+}$ (4)

Reactions in the Hold Tank

Dissolution

$Ca(OH)_2 \text{ (solid)} \longrightarrow Ca^{++} + 2\ OH^{-}$ (5)

Neutralization

$OH^{-} + HSO_3^{-} \longrightarrow SO_3^{=} + H_2O$ (6)

Oxidation

$SO_3^{=} + 1/2\ O_2 \longrightarrow SO_4^{=}$ (7)

Precipitation

$Ca^{++} + aSO_3^{=} + bSO_4^{=} + 1/2\ H_2O \longrightarrow Ca(SO_3)_a(SO_4)_b \cdot 1/2\ H_2O \text{ (solid)}$ (8)

$Ca^{++} + SO_4^{=} + 2\ H_2O \longrightarrow CaSO_4 \cdot 2\ H_2O \text{ (solid)}$ (9)

3.1.1 Reactions in the Scrubber

The major chemical reactions that occur in the scrubber include:

- Absorption of SO_2 from the flue gas into the slurry liquor
- Neutralization of the absorbed SO_2 by alkaline components in the liquor
- Dissolution of alkaline components from the slurry solids into the liquor
- Oxidation of sulfite species in the liquor to sulfate

Absorption of SO_2 from the flue gas into the slurry liquor is represented by Equation 1 of Table 3-1. In addition, some CO_2 is absorbed in the liquor. Without additional reactions the liquor would rapidly become saturated with SO_2 and CO_2, effectively terminating absorption.

Neutralization of the absorbed SO_2 is represented by Equation 2 of Table 3-1. The reaction in lime system is primarily that of the alkaline sulfite ion ($SO_3^=$) with SO_2 to form bisulfite (HSO_3^-) ions. This neutralization reaction is essentially instantaneous (Reference 9), thus allowing additional SO_2 to be absorbed. Absorbed CO_2 is neutralized by sulfite ($SO_3^=$) in a similar manner to form bicarbonate (HCO_3^-) and bisulfite (HSO_3^-).

Dissolution of alkali components is the limiting step in SO_2 removal. Alkalinity is maintained in the slurry liquor primarily by dissolving solid calcium sulfite ($CaSO_3$) to replenish the sulfite ion ($SO_3^=$) (Equation 3, Table 3-1). In addition, the slurry solids contain a small amount of calcium carbonate ($CaCO_3$) plus some residual calcium hydroxide [$Ca(OH)_2$] which dissolve and react with aqueous SO_2. The solids dissolution rate is a function of the solids concentration, the particle size distribution of the solids, and scrubber operating conditions, including liquid-to-gas ratio, holdup time in the scrubber, and slurry liquor pH (References 3 and 8).

Oxidation of the bisulfite ion (HSO_3^-) in the liquor phase to sulfate ($SO_4^=$) is represented by Equation 4 of Table 3-1. Oxygen for this reaction is supplied from the excess air in the flue gas. At Shawnee about 10 to 30 percent of the sulfite is oxidized. Although no reliable means of predicting the degree of oxidation have been developed at Shawnee, some general observations can be made (Reference 10):

- Increasing excess air tends to increase the rate of sulfite oxidation.
- Percent oxidation tends to increase with a decreasing SO_2 removal load.
- In general, operation at lower slurry pH gives higher sulfite oxidation.
- Most sulfite oxidation at Shawnee occurs in the scrubber and possibly the downcomer.
- Slurry liquor composition can affect oxidation at Shawnee. An increase in total dissolved solids lowers oxygen solubility, which decreases oxidation. However, increased dissolved solids may increase oxidation by increasing the sulfite concentration or by decreasing the average droplet size inside the scrubber, or both.
- Catalysts may affect sulfite oxidation. Potential oxidation catalysts are introduced from the flue gas (NO, NO_2), fly ash (metal oxides), lime (metal oxides), makeup water (metal ions), and from equipment erosion or corrosion products (Fe, Cr, Mn, and Cu compounds). There are no independent Shawnee data at this time to support the hypothesis of oxidation catalysis.

3.1.2 Reactions in the Hold Tank

The primary chemical reactions that occur in the hold tank are:

- Dissolution of lime

- Neutralization of the bisulfite species
- Oxidation of sulfite species
- Precipitation of reaction products

Dissolution of lime (Equation 5, Table 3-1) under normal operating conditions goes to nearly 100 percent completion in the hold tank. The dissolved lime raises the liquor pH, increases the Ca^{++} concentration, and converts the bisulfite (HSO_3^-) to sulfite ($SO_3^=$) (Equation 6, Table 3-1). A certain amount of sulfite ($SO_3^=$) is oxidized to sulfate ($SO_4^=$) (Equation 7, Table 3-1), owing to dissolved air from the scrubber and air entrained in the hold tank.

Because calcium sulfite ($CaSO_3$) is sparingly soluble, it precipitates (Equation 8, Table 3-1). A small amount of calcium sulfate ($CaSO_4$) is included as a solid solution with the sulfite precipitate. Up to about 12 to 15 mole percent sulfate can be included in the sulfite solid solution. Thus, if sulfite oxidation in the scrubber system is limited to less than 12 to 15 percent (Reference 11), the scrubber liquor will be unsaturated in sulfate and the system will operate free of gypsum ($CaSO_4 \cdot 2H_2O$) precipitation and scaling. This mode of operation has been frequently observed at Shawnee and at the EPA-IERL pilot plant (References 3 and 12).

If sulfite oxidation is greater than 12 to 15 percent, the excess sulfate will precipitate as gypsum ($CaSO_4 \cdot 2H_2O$) (Equation 9, Table 3-1). Calcium sulfate has a tendency to supersaturate in the scrubber liquor and to precipitate as hard scale on scrubber surfaces. As a practical matter, if gypsum saturation is limited throughout the scrubber system to less than about 135 percent, gypsum crystals will not form on scrubber surfaces, and hence, there will be no gypsum scaling (References 1 and 12). Furthermore, at least about 3 percent gypsum solids by weight in the slurry will provide sufficient gypsum crystallization sites to prevent supersaturation and scaling.

Calcium carbonate ($CaCO_3$) also precipitates in the hold tank as a result of bicarbonate ion (HCO_3^-) reacting with hydroxide (OH^-). Although some of the $CaCO_3$ redissolves in the scrubber, it is the main solid waste product that limits lime utilization in the system. In addition, there is a small amount of "dead burned" lime in the system that has limited reactivity and becomes part of the waste product solids. "Dead burned" lime results primarily from overheating due to temperature control limitations inherent in the calcining process by which quick lime is made.

3.2 FACTORS AFFECTING LIME SCRUBBING

The quantitative effects of operating conditions on SO_2 removal are presented in Section 7. This section will focus on the qualitative factors affecting reliable, scale-free scrubber operation.

3.2.1 Operating pH

At Shawnee the scrubber inlet pH is normally set between 7 and 8 when operating with lime. The critical factor is to maintain scrubber inlet pH below about 9 to prevent carbonate scaling and scrubber outlet pH below about 5.5 to prevent sulfite scaling (Reference 5, Section 7.2).

If the scrubber inlet pH is allowed to exceed 9, sufficient CO_2 from the flue gas will dissolve to react with $Ca(OH)_2$ in the slurry and precipitate carbonate scale.

Normally in lime scrubbing, calcium sulfite dissolves in the scrubber to replenish the sulfite ion that reacts with SO_2 to form soluble bisulfite (Equation 2, Table 3-1). However, it has been found at Shawnee that at a scrubber outlet pH above about 5.5, the calcium sulfite will precipitate in the bottom of the scrubber and form scale. Presumably, under scaling conditions, excess lime [$Ca(OH)_2$] dissolves faster than sulfite is reacted causing the calcium ion concentration to increase and calcium sulfite to precipitate.

Thus, if sulfite scaling is observed in a lime scrubber, it can be reduced or eliminated entirely by reducing the scrubber inlet pH. For a given scrubber in lime service, an operating pH should be chosen that is sufficiently high for good removal but sufficiently low to prevent sulfite and carbonate scaling. At Shawnee this pH has been in the range of 7 to 8 at the scrubber inlet.

3.2.2 Alkali Utilization

Lime systems inherently operate at high alkali utilization (moles SO_2 absorbed per mole of Ca added). Typically at Shawnee, alkali utilization ranges about 90 to 95 percent. Any attempt to improve SO_2 removal by increasing lime rate (thus decreasing utilization) would result in higher pH and scaling as described above.

3.2.3 Recirculated Slurry Solids Concentration

The recirculated slurry must have sufficient solids to provide adequate surface area for alkali dissolution and to provide crystal sites for product precipitation. Additionally, a smaller filter or centrifuge is required when operating at higher solids concentration. On the other hand, high solids concentrations contribute to equipment erosion and to system fouling (especially of the mist eliminator).

The normal mode of operation with lime slurry at Shawnee is at 15 weight percent slurry solids when operating with high fly ash loading and at 8 weight percent solids with low fly ash loading. As the fly ash constituted about 40 weight percent of the slurry solids, the concentration of calcium based solids was about the same in both cases. These concentrations represented a compromise among the factors listed above.

In a few runs the slurry solids concentration was dropped to only 4 percent with low fly ash loading (Reference 4, Section 7.2). Test results were essentially the same. However, slight scaling of the scrubber internals resulted with the 4 percent slurry. Other tests (Reference 5, Section 7.2) indicated that slurry solids below about 7 percent (low fly ash loading) caused scaling and a drop in SO_2 removal. Thus, a minimum of about 7 percent slurry solids concentration, exclusive of fly ash, is recommended.

3.2.4 Effluent Hold Tank Residence Time

A majority of the lime scrubbing runs at Shawnee were made at 12 to 17 minute effluent hold tank residence times. However, satisfactory runs (Reference 4, Section 7.2) were made at a residence time as low as 3 minutes. Only one combination, 3 minutes residence time and 4 percent slurry solids concentration (low fly ash loading), resulted in some scaling. At 8 percent slurry solids no scaling was observed.

As noted earlier, lime reacts with the effluent slurry in the hold tank to precipitate a sulfite/sulfate product. Residence time is considered satisfactory as long as precipitation is essentially complete in the hold tank. In the Shawnee configuration with 8 percent slurry solids concentration, 3 minutes was found to be adequate.

3.2.5 Liquid-to-Gas Ratio

The relationship of liquid-to-gas ratio to scaling tendencies is manifested by its effect on effluent pH. At very low liquid-to-gas ratio a low effluent pH could encourage sulfite oxidation and thereby promote gypsum scaling. Low pH, however, should not affect sulfite scaling.

The quantitative relationships between liquid-to-gas ratio and SO_2 removal efficiency for the two types of scrubbers operated at Shawnee are summarized in Section 7.

3.2.6 Effect of Chloride on pH and SO_2 Removal

Chloride exists in coal and is introduced as HCl with flue gas into the scrubber where it is absorbed by the scrubber liquor. Chloride concentration in the liquor is dependent on its content in coal and the scrubber liquor loop closure.

At a constant stoichiometric ratio (i.e., constant moles of lime added per mole of SO_2 absorbed), increasing the chloride concentration reduces the equilibrium pH and the liquor alkalinity. As the Cl^- concentration increases, the Ca^{++} concentration increases to maintain ion balance. The Ca^{++} concentration is also related to the $CO_3^=$ concentration by the solubility product equation:

$$(Ca^{++})\ (CO_3^=) = K_{CaCO3} = \text{constant} \qquad (3\text{-}2)$$

The $CO_3^=$ concentration, in turn, is related to the H^+ concentration (at constant CO_2 and SO_2 partial pressures) as follows:

$$(H^+)^2(CO_3^=) = K_{H_2CO_3} \times p_{CO_2} = \text{constant} \qquad (3\text{-}3)$$

Thus, as Ca^{++} concentration increases, $CO_3^=$ concentration decreases (to keep their product constant). The H^+ concentration must then increase (or alternately, the pH must decrease) in accordance with Equation 3-3.

To raise the pH again to a point at which it would be without the chloride, more lime is required. Thus, at a constant scrubber inlet liquor pH, SO_2 removal should increase with increasing chloride concentration. This increased SO_2 removal is not a direct result of the presence of Cl^-, but rather is a result of the higher lime stoichiometry required in the presence of chloride to maintain a constant pH.

3.2.7 Saturations and Scaling in Lime Wet Scrubbing Systems

As previously mentioned, if the saturation level of gypsum in the scrubber slurry liquor exceeds about 135 percent, calcium sulfate will precipitate in the scrubber as hard scale. Results from the lime tests indicated that the gypsum saturation level can be reduced by:

- Increasing percent solids recirculated
- Increasing effluent residence time

- Increasing liquid-to-gas ratio and
- Decreasing flue gas inlet SO_2 concentration (SO_2 absorption rate)

It was also noted that lime addition to the scrubber downcomer, instead of the effluent hold tank, substantially reduces the gypsum saturation. This effect is due to the high calcium sulfite precipitation rate in the downcomer where lime is added, which tends to pre-emt sulfite oxidation. This latter innovation allows for operation at reduced percent solids recirculated and/or residence time.

3.2.8 Effect of Fly Ash

Tests were made at Shawnee with both high fly ash loading (3 - 6 gr/dry scf in the flue gas) and low fly ash loading (0.04 - 0.20 gr/dry scf). The presence of fly ash in scrubber slurry has both process and mechanical implications. Observed process effects due to fly ash were:

- At a controlled scrubber inlet pH of 8, lime utilization for the tests with low fly ash loading averaged about 93 percent, compared with about 88 percent for runs made with high fly ash loading under similar test conditions.*
- The filter cake solids contents from the low fly ash loading runs were 5 to 10 weight percentage points lower than those from the corresponding runs with high fly ash loading.
- The total dissolved solids concentrations, particularly chloride species, were higher for the low fly ash loading runs than for the runs with high fly ash loading because of the tighter water balance resulting from the reduced waste solids discharge.

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*This difference was believed to be caused by the acidic fly ash (verified by the laboratory pH measurement of fly ash/water slurry) which releases its acidity from absorbed SO_3 under scrubber conditions, even though the fly ash pond liquor at Shawnee is alkaline after a prolonged period of leaching.

- Reduced waste solids discharge implies reduced makeup water requirements. This effect could be detrimental if the quantity of makeup water is limited to that below the minimum required for mist eliminator flush (see Sections 10 and 11).

Mechanical effects relate to the detrimental abrasion and/or erosion effects of fly ash. An illustration of this effect is provided by a comparison of the spray tower nozzle wear rate in high and low fly ash loading operation. Eight Bete stainless steel nozzles (No. TF48FCN) were tested for 1565 hours on lime slurry with low fly ash loading. During the testing period, the average flow rate per nozzle was 45 gpm at a 10 psi pressure drop. Most of the operation, approximately 1200 hours, was with 8 percent solids slurry. The remainder was with 4 percent solids slurry. During the testing individual nozzles lost from 0.93 to 2.43 percent of their initial weight because of erosion (about 1 percent per 1000 hours).

Earlier testing of these nozzles, before the Advanced Test Program, with lime and limestone slurries containing high fly ash loadings had resulted in an average weight loss of approximately 28 percent in 4320 hours (about 6 percent per 1000 hours). This was a considerably higher erosion rate than observed in operation with slurry having low fly ash loading. The average flow rate per nozzle was also 45 gpm at a 10 psi pressure drop during the tests with high fly ash loading.

3.3 CONTROL OF LIME SYSTEMS

Two of the major parameters affecting the SO_2 removal efficiency and the reliable, scale-free operation of lime scrubbing systems are the pH and the weight percent solids concentration of the recirculating slurry.

Control of the scrubber inlet pH is easily achieved by regulating the quantity of lime added to the effluent hold tank or scrubber downcomer. In practice, this operation is readily automated by coupling the pH signal to the lime addition pump drive. The pH level is chosen to maximize SO_2 removal while minimizing lime usage, carbonate scaling at the scrubber inlet, and sulfite scaling at the scrubber outlet.

Control of the recirculated solids concentration is achieved by regulating the bleed flow rate from the effluent hold tank to the dewatering area. The magnitude of the bleed flow rate is adjusted periodically following comparison of the desired solids concentration with the actual value. At Shawnee, slurry solids concentration is monitored continuously via Ohmart radiation density meters and Dynatrol U-tube density meters, and periodically via slurry filtration and drying techniques. A constant liquid level in the effluent hold tank is achieved by balancing the bleed flow rate with the feed forward flow rate of clarified liquor from the dewatering area.

Overall system levels are maintained by matching the water outputs through flue gas humidification, entrainment and wet waste solids with water inputs through alkali makeup, mist eliminator flush water, pump seal water and any other additional makeup water.

Operating experience with lime wet scrubbing systems has identified sequences of operation that permit reliable system startup and shutdown. A primary consideration during initial startup is the quantity of fresh lime in the system. The amount of lime should be adequate to avoid a precipitous drop in slurry pH when initial contact with SO_2 bearing flue gas is made. At the same time, an excess of lime at startup is undesirable because of the possibility of scaling at high dissolved calcium concentrations. Considerations relating to shutdown are primarily mechanical and are more critical during the winter months. Pertinent precautions include: draining and flushing the valves, pumps, sensing elements and piping to avoid freeze damage; removing in-line pH sensing elements; continuing agitation in slurry hold tanks to prevent settling; and putting the clarifier/thickener underflow on recycle to prevent line pluggage, preferably using a pump that does not require seal water (such as a Moyno pump).

A thorough study of the response of lime wet scrubbing systems to abrupt changes in gas flow rate (liquid-to-gas ratio) and inlet SO_2 concentration level was made during two separate testing blocks. The first block was operated with natural oxidation and the second with forced oxidation. During the 1143 hour natural oxidation test block (Reference 3, Section 6), the gas flow rate was varied between 17,000 and 35,000 acfm (at 300°F) while the inlet SO_2 concentration ranged from 1500 to 4400 ppm. No problems due to the cycling gas rate and gas composition* were encountered. The condition of the mist eliminator remained almost unchanged, with a 2 percent restriction of the total cross-sectional area by dust-like solids at the conclusion of test block.

During the 779 hour two-loop forced-oxidation test block (Reference 5, Section 7.2.11), the gas flow rate was varied between 18,000 and 35,000 acfm (at 300°F) while the inlet SO_2 concentration ranged from 2300 to 3600 ppm. Again, no equipment problems due to cycling gas rate and gas composition were encountered.

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*It should be noted that with the boiler operating philosophy at Shawnee, significant increase in flue gas oxygen concentration accompanies operation at low boiler load.

Average SO_2 removal for the entire block was 88 percent at 2950 ppm average inlet SO_2 concentration. This corresponds to an average emission 0.9 lb SO_2/MM Btu.

Section 4
LIMESTONE SCRUBBING

Limestone is a naturally occuring mineral consisting primarily of calcium carbonate. It is normally delivered to Shawnee from the Fredonia Quarries in Kentucky in the form of crushed stones averaging about 1-1/2 inches in size. The crushed stones are dried and ground to about 95 percent less than 325 mesh in a dry ball mill remaining from an earlier EPA-sponsored dry-limestone injection program. The stones normally contain 97 weight percent $CaCO_3$, 1 weight percent $MgCO_3$, and 2 weight percent inerts.

In this section a simplified description of limestone scrubbing chemistry is presented, followed by a discussion of operating conditions and control procedures.

The chemistry described was compiled from several sources and is not wholly based on results at the Shawnee Test Facility. Documentation of sources is given where possible. Details of the chemistry presented are based on interpretation of observations to date and are subject to modification as more information becomes available.

4.1 CHEMISTRY OF LIMESTONE SCRUBBING

The overall reaction of limestone with SO_2 may be represented by:

$$CaCO_3 + SO_2 \longrightarrow CaSO_3 + CO_2 \tag{4-1}$$

One mole of limestone reacts with one mole of SO_2 to produce one mole of calcium sulfite and one mole of carbon dioxide. Like lime scrubbing, the chemistry of limestone scrubbing is also complex.

Table 4-1 contains equations that represent the major chemical reactions that occur during wet scrubbing of SO_2 with limestone slurries under normal operating conditions. These conditions are:

Absorbent slurry liquor pH = between 5.0 and 6.0 at the scrubber inlet and between 4.5 and 5.5 at the scrubber outlet

Stoichiometric ratio (moles of limestone added per mole of SO_2 absorbed) = 1.1 to 1.6

These equations are not meant to be all inclusive, for the same reasons discussed in Section 3.1.

4.1.1 Reactions in the Scrubber

SO_2 reacts with limestone in the scrubber to produce Ca^{++} and HSO_3^- in the liquor, and to precipitate calcium sulfite. As in lime scrubbing, most sulfite oxidation probably occurs in the scrubber. Unlike lime scrubbing, in limestone scrubbing there is considerable carbon dioxide desorption in the scrubber (as well as in the hold tank).

Table 4-1

MAJOR CHEMICAL REACTIONS INVOLVED IN LIMESTONE SCRUBBING OF SO_2

Reactions in the Absorber

Absorption

$$SO_2\,(\text{gas}) \rightleftharpoons SO_2\,(\text{aqueous}) \tag{1}$$

$$CO_2\,(\text{gas}) \rightleftharpoons CO_2\,(\text{aqueous}) \rightleftharpoons H_2CO_3 \tag{2}$$

Desorption

$$HCO_3^- + SO_2\,(\text{aqueous}) + H_2O \rightleftharpoons H_2CO_3 + HSO_3^- \tag{3}$$

$$H_2CO_3 \rightleftharpoons CO_2\,(\text{gas}) + H_2O \tag{4}$$

Neutralization

$$HCO_3^- + SO_2\,(\text{aqueous}) + H_2O \rightleftharpoons H_2CO_3 + HSO_3^- \tag{5}$$

$$SO_3^= + SO_2\,(\text{aqueous}) + H_2O \rightleftharpoons 2HSO_3^- \tag{6}$$

$$CaCO_3\,(\text{solid}) + 2SO_2\,(\text{aqueous}) + 2H_2O \rightleftharpoons Ca^{++} + 2HSO_3^- + H_2CO_3 \tag{7}$$

Oxidation

$$HSO_3^- + 1/2O_2 \rightleftharpoons SO_4^= + H^+ \tag{8}$$

Precipitation

$$Ca^{++} + (1-x)SO_3^= + xSO_4^= + 1/2\,H_2O \rightleftharpoons Ca(SO_3)_{1-x}(SO_4)_x \cdot 1/2\,H_2O(\text{solid}) \tag{9}$$

Reactions in the Hold Tank

Dissolution and Desorption

$$CaCO_3\,(\text{solid}) + HSO_3^- \rightleftharpoons Ca^{++} + SO_3^= + HCO_3^- \tag{10}$$

$$HCO_3^- + HSO_3^- \rightleftharpoons H_2CO_3 + SO_3^= \tag{11}$$

$$H_2CO_3 \rightleftharpoons CO_2\,(\text{aqueous}) \rightleftharpoons CO_2\,(\text{gas}) \tag{12}$$

Oxidation

$$HSO_3^- + 1/2O_2 \rightleftharpoons SO_4^= + H^+ \tag{13}$$

Precipitation

$$Ca^{++} + SO_4^= + 2H_2O \rightleftharpoons CaSO_4.\,2H_2O\,(\text{solid}) \tag{14}$$

$$Ca^{++} + (1-x)SO_3^= + (x)SO_4^= + 1/2H_2O \rightleftharpoons Ca(SO_3)_{1-x}(SO_4)_x \cdot 1/2H_2O\,(\text{solid}) \tag{15}$$

4.1.2 Reactions in the Hold Tank

Limestone also dissolves in the hold tank, causing calcium sulfite to precipitate. Gypsum precipitates in the hold tank as calcium sulfite/sulfate solid solution and also as a separate phase if the gypsum saturation is greater than 100 percent (Reference 13). Note that both calcium sulfite and gypsum have a strong tendency to become supersaturated in liquor without precipitation.

4.1.3 Reactions at High Stoichiometry

Stoichiometry is an important controllable variable in limestone scrubbing of SO_2. At high stoichiometry, where the moles of $CaCO_3$ added per mole of SO_2 absorbed is greater than about 1.3, $CaCO_3$ dissolution occurs primarily in the scrubber (Equation 7, Table 4-1 and Reference 8). For every mole of SO_2 absorbed, 1/2 mole of Ca^{++} can precipitate in the hold tank or in the scrubber as $CaSO_3$ (as a solid solution with calcium sulfate) or $CaSO_4$.

4.1.4 Reactions at Low Stoichiometry

At low stoichiometry, (where the moles of $CaCO_3$ added per mole of SO_2 absorbed are less than or equal to 1.1), $CaSO_3$ dissolution in the scrubber may occur, as in the lime system, and contribute to SO_2 removal. The equation is (Reference 8):

$$CaSO_3 + SO_2 + H_2O \rightleftharpoons Ca^{++} + 2HSO_3^- \qquad (4\text{-}2)$$

According to Equation 4-2, twice as much Ca^{++} is released per mole of SO_2 absorbed by the reaction of SO_2 with $CaSO_3$ than by the comparable bisulfite producing reaction of SO_2 with $CaCO_3$ (Equation 7, Table 4-1). Therefore, slurry leaving the scrubber will have more dissolved Ca^{++} in it at low stoichiometry than at high stoichiometry, as long as Ca^{++} precipitation in the absorber as gypsum does not occur fast enough to reduce the Ca^{++} concentration to its equilibrium value.

4.2 FACTORS AFFECTING LIMESTONE SCRUBBING

The quantitative effects of operating conditions on SO_2 removal are presented in Section 7. This section discusses the qualitative factors influencing reliable, scale-free scrubber operation.

4.2.1 Operating pH

At Shawnee the scrubber inlet pH is normally set between 4.5 and 6.0 when operating with limestone. The critical factor is to control scrubber inlet pH below about 6 to prevent carbonate deposition at the inlet. Also, the scrubber outlet pH was controlled above about 4.0 to prevent sulfite blinding of limestone and to mitigate downcomer corrosion.

In limestone scrubbing, if the scrubber inlet pH is allowed to exceed 6, the excess limestone deposits as soft scale at the scrubber inlet. Additionally, a scrubber outlet pH above 5.5 may cause sulfite scaling at the scrubber outlet, depending on the SO_2 make-per-pass. Presumably, for an outlet pH above 5.5, excess limestone dissolves faster than calcium sulfite is reacted (Equations 6 and 7, Table 4-1), causing the calcium ion concentration to increase and calcium sulfite to precipitate.

Normally in limestone scrubbing, calcium carbonate dissolves in the scrubber to produce the bicarbonate ion that reacts with SO_2 to form soluble bisulfite and evolve CO_2 (Equations 3 and 4, Table 4-1). However, it has been observed at Shawnee that at a scrubber outlet pH below about 4.0, the bisulfite ions may coat (blind) the fresh limestone particles and thereby reduce their utilization.

Thus, reliable operation of a limestone scrubber can be obtained by maintaining the scrubber outlet pH between 4.0 and 5.5. For a given scrubber in limestone service, an inlet pH should be chosen that is sufficiently high for good SO_2 removal but adequately balanced at the outlet to prevent sulfite scaling and limestone blinding. At Shawnee this inlet pH has been in the range of 4.5 to 6.0.

4.2.2 Alkali Utilization

Extensive testing indicated an increase in limestone utilization with increasing hold tank residence time, greater number of hold tanks, and decreasing scrubber inlet pH. At Shawnee limestone utilization normally varied from about 60 percent at a scrubber inlet liquor pH of 6.0 to about 95 percent at a scrubber inlet liquor pH of 5.2. Operation at reduced scrubber inlet liquor pH, however, caused a reduction in SO_2 removal efficiency when other test conditions were held constant.

4.2.3 Recirculated Slurry Solids Concentration

The recirculated slurry must have sufficient solids to provide adequate surface area for alkali dissolution and to provide crystal sites for product precipitation. Also, a smaller filter or centrifuge is required when operating at higher solids concentration. On the other hand, high solids concentrations contribute to equipment erosion and to fouling of the system (especially of the mist eliminator).

The normal mode of operation with limestone slurry at Shawnee was at 15 weight percent slurry solids when operating with high fly ash loading and at 8 weight percent solids with low fly ash loading. Because the fly ash constituted about 40 weight percent of the slurry solids, the concentration of calcium based solids was about the same in both cases. These concentrations represented a compromise among the factors listed above.

As with lime scrubbing, scaling in the limestone scrubber occurred at slurry solids concentrations below about 7 percent, exclusive of fly ash. Furthermore, a significant drop in SO_2 removal was experienced at slurry solids concentrations below this level. This latter effect was much stronger for limestone scrubbing than for lime scrubbing.

4.2.4 Effect of Forced Oxidation*

Because $CaSO_3$ dissolution can be an important scrubbing mechanism at low stoichiometry in the limestone system (and at normal stoichiometry in the lime system), forced oxidation in the hold tank of $CaSO_3$ to $CaSO_4$, which eliminates this scrubbing mechanism, could result in low SO_2 removal efficiencies. Forced oxidation has been investigated at the EPA-IERL pilot plant. Preliminary results indicate that CO_2 stripping caused by the air sparging enhances limestone dissolution, and hence nullifies any possible adverse effects on SO_2 removal caused by forced oxidation.

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* Forced oxidation represents any means external to the scrubber by which essentially all of the $CaSO_3$ is oxidized to gypsum.

4.2.5 Effect of Fly Ash

At the same limestone utilization, the scrubber inlet pH for runs with low fly ash loading tended to be 0.3 to 0.4 pH unit higher than for runs with high fly ash loading. This is similar to the observations made during lime tests with a controlled scrubber inlet pH of 8, in which lime utilization averaged about 93 percent for runs with low fly ash loading, compared with abouut 88 percent for runs with high fly ash loading (Section 3.2.8).

Effects on total dissolved solids concentration, water balance, along with the mechanically induced results of abrasion and/or erosion are similar to those for lime systems (see Section 3.2.8).

4.2.6 Effect of Hold Tank Residence Time and Configuration

Unlike lime scrubbing systems where approximately 3 minutes of residence time was found adequate with a single tank configuration, limestone scrubbing systems require about 5 minutes residence time. Greater residence time is required because of the lower limestone equilibrium solubility and slow dissolution rate. However, the total residence time can be reduced by use of a plug flow hold tank reactor. Kinetic theory shows that for a continuous system where the reaction order is greater than zero, raw materials are more completely converted in plug flow than in a backmix reactor with the same residence time. This concept for improving limestone utilization was successfully tested at the EPA-IERL pilot plant and the Shawnee

Test Facility (References 3 and 8). Hold tank configurations tested and the results obtained are described in Section 4.3.

4.3 LIMESTONE UTILIZATION AS A FUNCTION OF SCRUBBER INLET pH

Tests were conducted primarily to correlate stoichiometric ratio (the reciprocal of alkali utilization) with scrubber inlet liquor pH, effluent hold tank residence time, and hold tank design (Reference 3). Hold tank configurations tested included a single backmix hold tank and three backmix hold tanks in series (to simulate a plug flow reactor). No attempt was made to account for secondary variables such as chloride concentration in the slurry liquor, which ranged from 1500 to 6500 ppm during testing. Models that take such secondary variables into consideration are described in Section 7.

For each combination of hold tank residence time and hold tank design, tests were conducted to cover a range of values of scrubber slurry liquor pH. Normally the systems were run for about 4 to 5 days at a specified level of pH. During testing, the stoichiometric ratios were determined every 4 hours from solids analyses of the scrubber recirculation slurry.

Data showing the relationship between stoichiometric ratio and scrubber inlet liquor pH for the venturi/spray tower system are plotted in Figures 4-1, 4-2, and 4-3 for residence times of 20, 12, and 6 minutes, respectively. The stoichiometric ratio/pH relationship was best defined for the 12 minutes residence time tests. As expected, scatter in the data was greatest at 6 minutes residence time, where pH recovery time was limited and small varia-

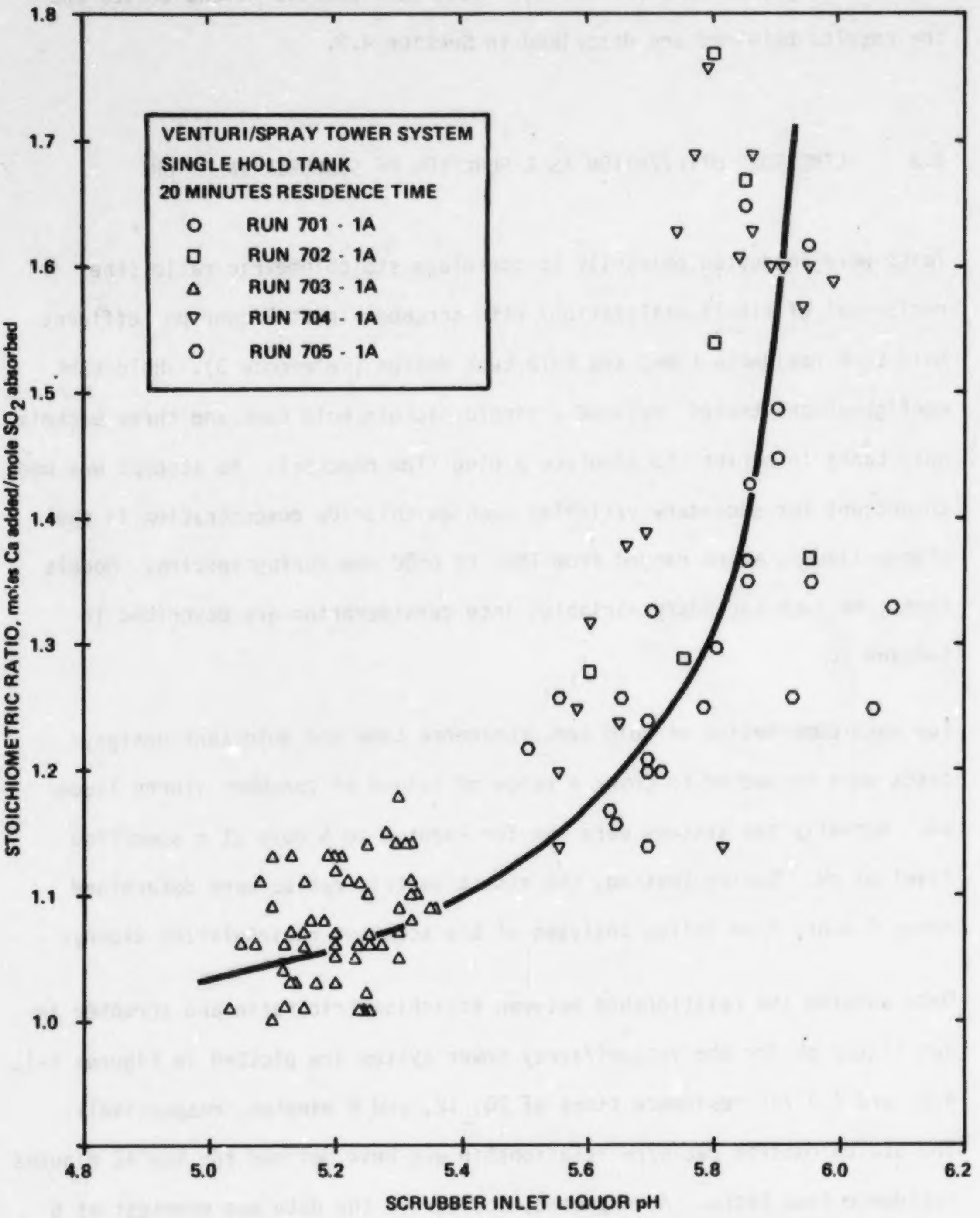

Figure 4-1. Stoichiometric Ratio versus Scrubber Inlet Liquor pH in the Venturi/Spray Tower System with a Single Hold Tank at 20 minutes Residence Time

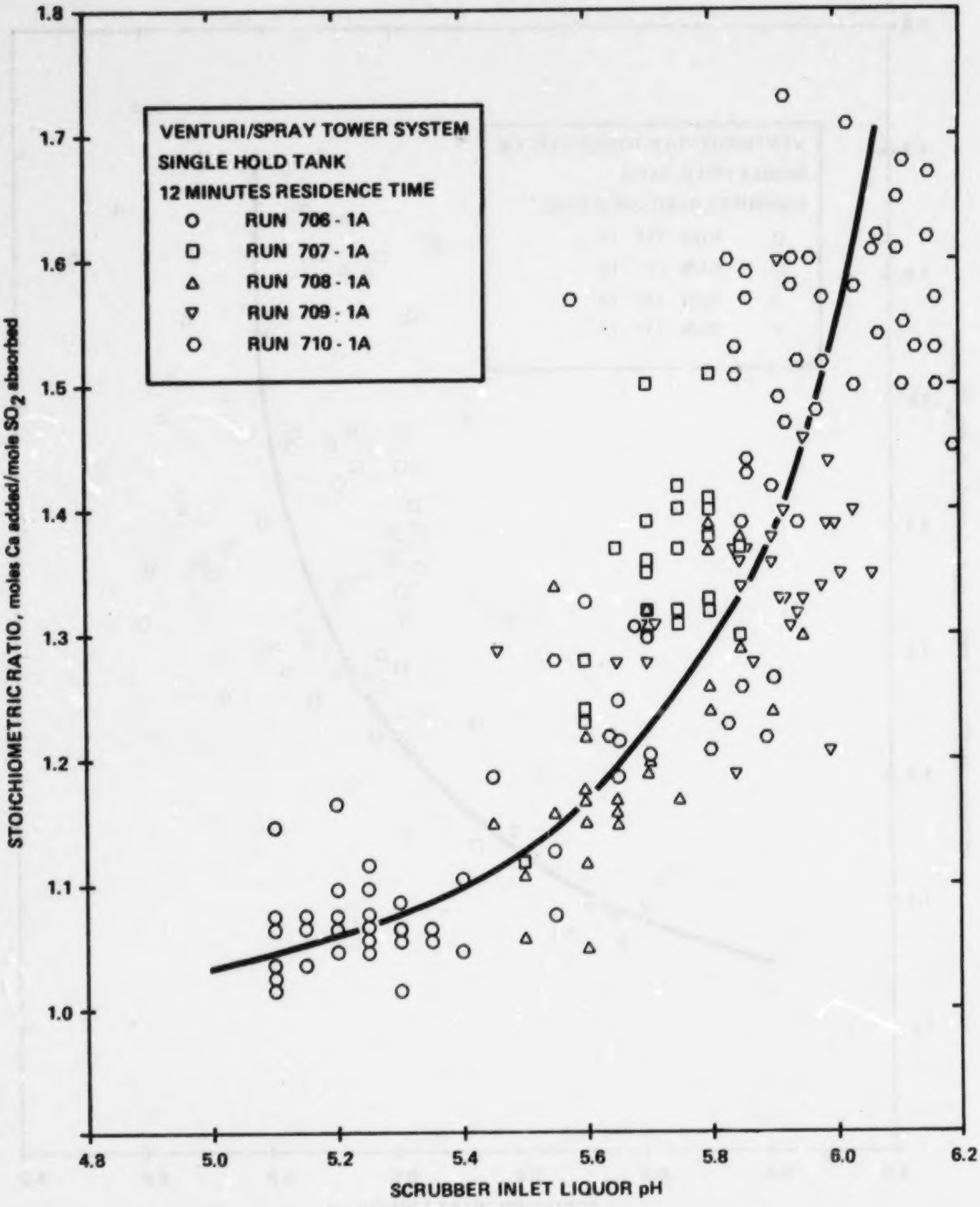

Figure 4-2. Stoichiometric Ratio versus Scrubber Inlet Slurry pH in the Venturi/Spray Tower System with a Single Hold Tank at 12 minutes Residence Time

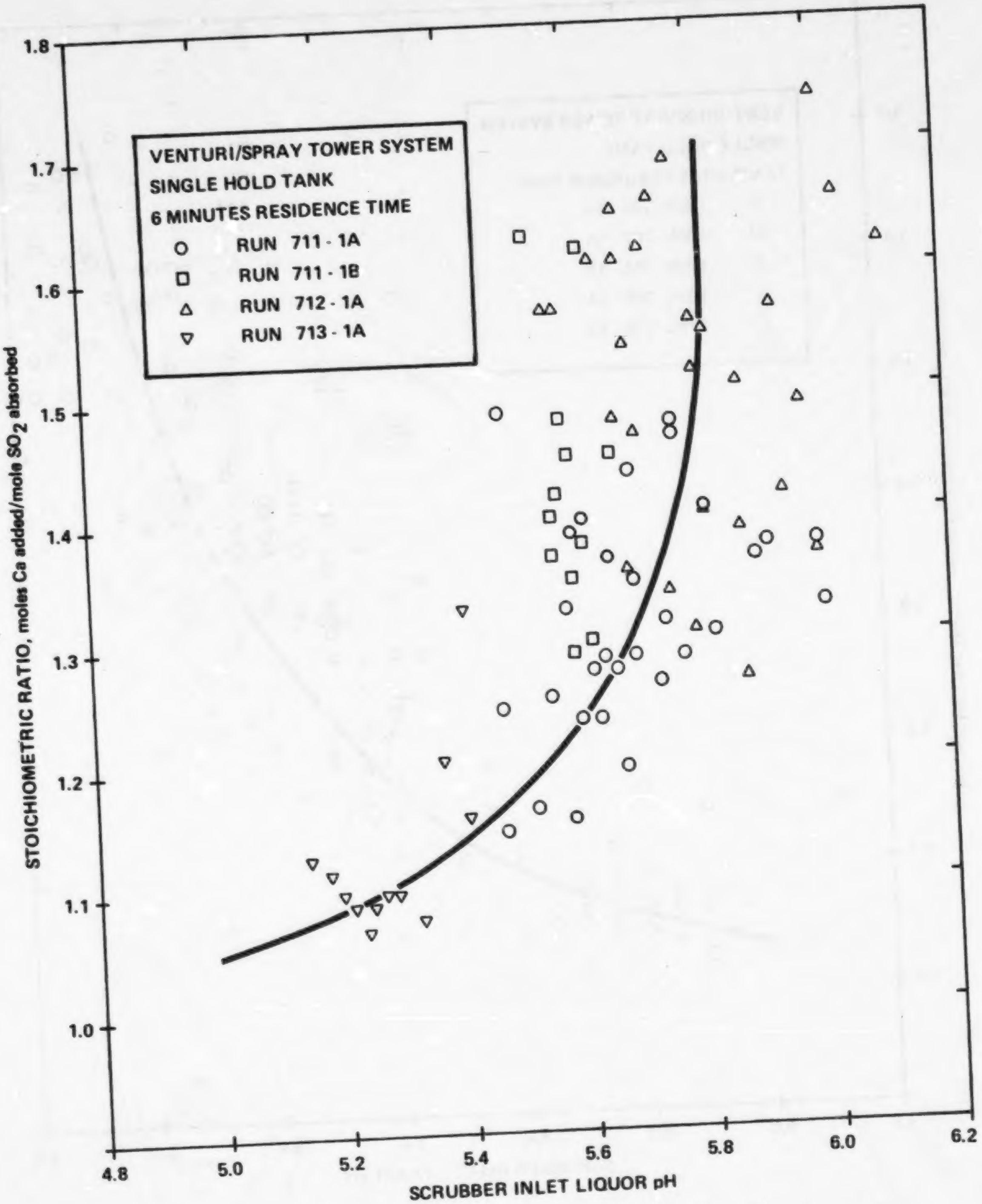

Figure 4-3. Stoichiometric Ratio versus Scrubber Inlet Liquor pH in the Venturi/Spray Tower System with a Single Hold Tank at 6 minutes Residence Time

tions in tank level resulted in significant changes in residence time. At 20 minutes residence time only a limited number of data were obtained at higher pH values.

Sight-average curves drawn through the data in Figures 4-1 through 4-3 are compared in Figure 4-4. In Figure 4-4 a tendency for lower stoichiometric ratio at a given pH can be seen as residence time increases. However, above a pH of 5.8 the sight-average curve for 20 minutes residence time fell between 6 and 12 minutes. This inconsistency is indicative of the broad scatter of the data.

In the TCA system, hold tank configurations tested included: (i) single hold tank at 12 minutes residence time; (ii) three hold tanks in series at 14.4 minutes total residence time (5.2, 2.6 and 6.6 minutes, respectively); and (iii) three hold tanks in series at 10.8 minutes total residence time (4.6, 2.3, and 3.9 minutes, respectively).

Results of the utilization testing for these three configurations are plotted as stoichiometric ratio versus inlet liquor pH in Figures 4-5, 4-6, and 4-7, respectively. Sight-drawn averages from Figures 4-5 through 4-7 are compared in Figure 4-8. For the runs with three tanks in series, there was no significant difference between 10.8 minutes and 14.4 minutes residence time. However, there was a distinct difference between operation with a single tank and that with three tanks in series at pH values greater than about 5.0. For example, at a scrubber inlet liquor pH of 5.6, the stoichiometric ratio averaged 1.19 with a single hold tank as compared with 1.11 with three tanks in series. The latter is a 7 percent improvement in limestone utilization. At higher pH the improvement was greater; e.g., at pH 5.8, the improvement in utilization was 14 percent.

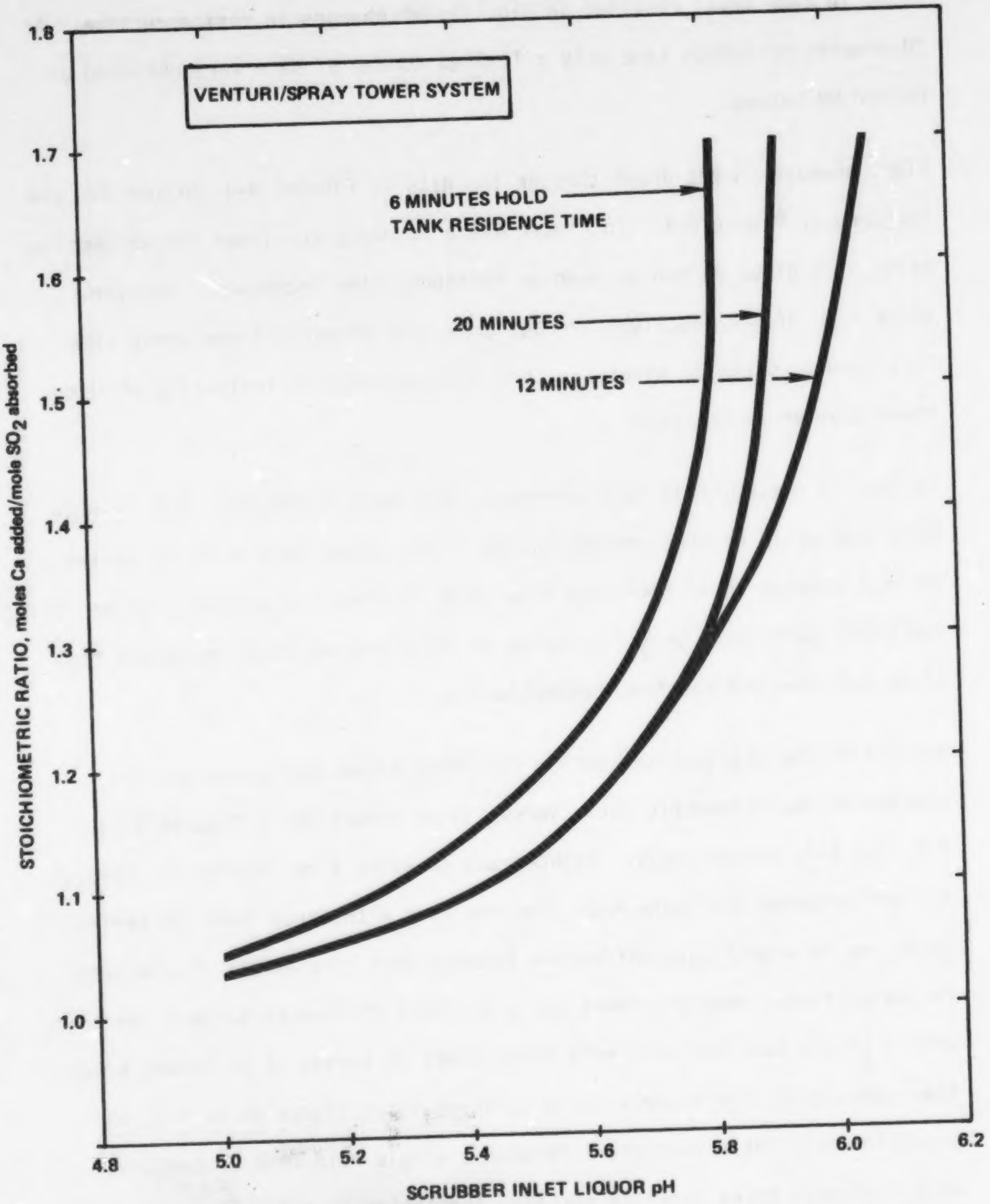

Figure 4-4. The Effect of Effluent Hold Tank Residence Time and Scrubber Inlet Liquor pH on Stoichiometric Ratio in the Venturi/Spray Tower System

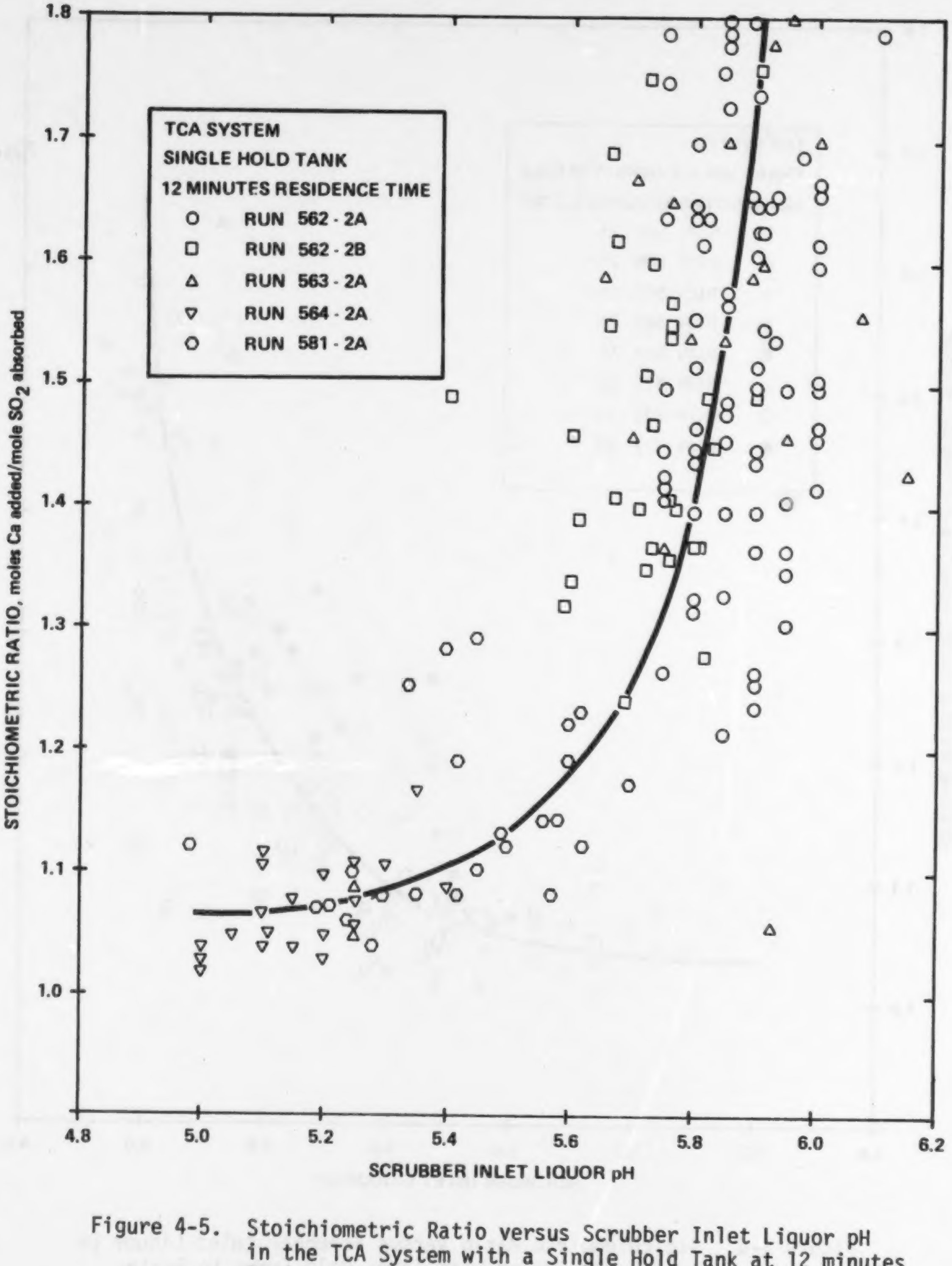

Figure 4-5. Stoichiometric Ratio versus Scrubber Inlet Liquor pH in the TCA System with a Single Hold Tank at 12 minutes Residence Time

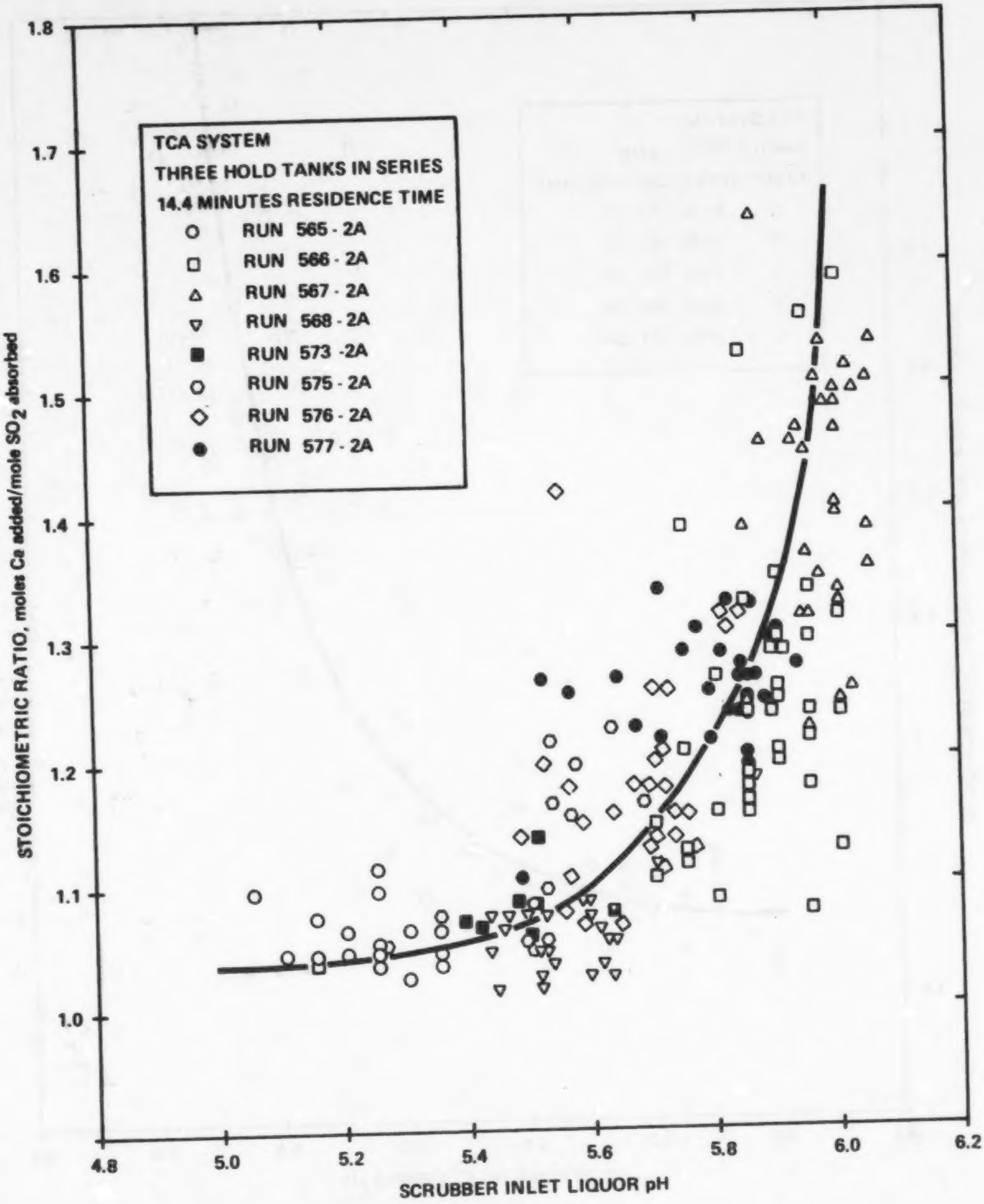

Figure 4-6. Stoichiometric Ratio versus Scrubber Inlet Liquor pH in the TCA System with Three Hold Tanks in Series at 14.4 minutes Residence Time

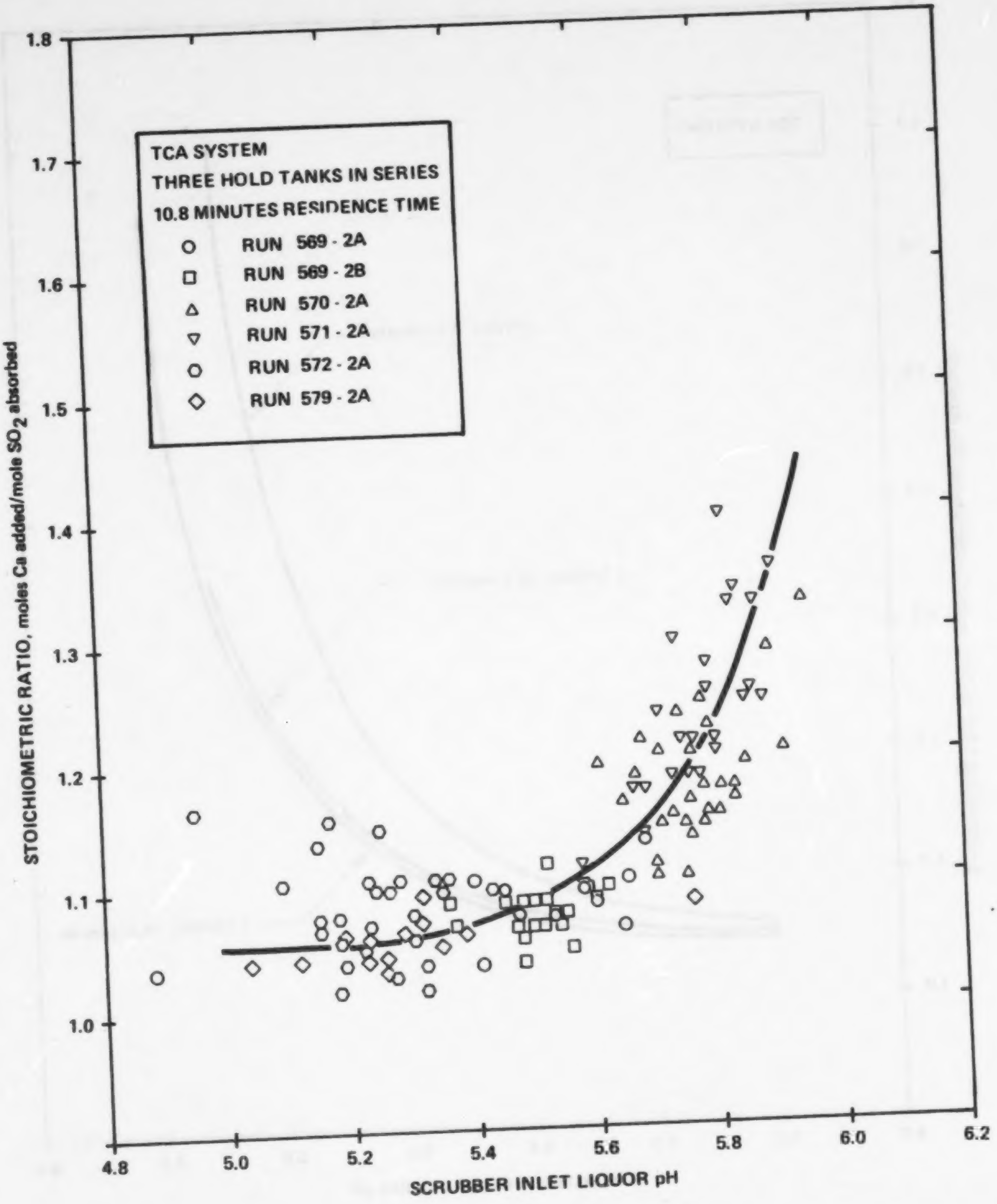

Figure 4-7. Stoichiometric Ratio versus Scrubber Inlet Liquor pH in the TCA System with Three Hold Tanks in Series at 10.8 minutes Residence Time

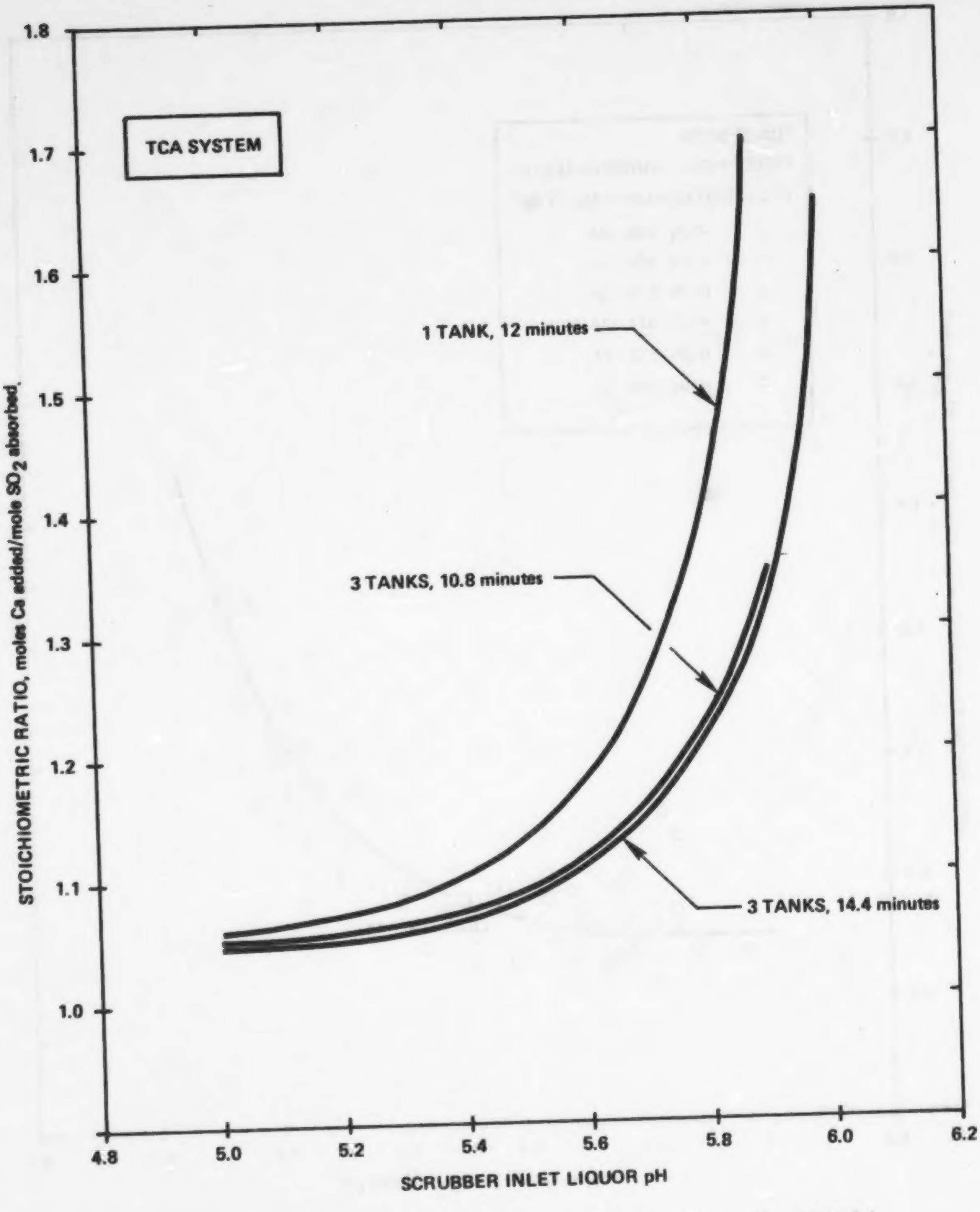

Figure 4-8. The Effect of Scrubber Inlet Liquor pH and Hold Tank Configuration on Stoichiometric Ratio in the TCA System

4.4 LIMESTONE TYPE AND GRIND TEST RESULTS

Six tests were conducted at Shawnee to investigate the effect of limestone type and grind on system performance (Reference 5, Section 10). System performance was evaluated in terms of SO_2 removal and scrubber inlet slurry pH at a controlled stoichiometric ratio of 1.2 moles Ca/mole SO_2 removed. Limestone type, limestone grind, effluent hold tank (EHT) residence time, and effluent hold tank configuration were varied.

The levels of independent variables evaluated were:

- Limestone grind (Table 4-2) - fine (96 percent less than 325 mesh) versus coarse (65 to 69 percent less than 325 mesh)
- Limestone type - Fredonia White versus Longview, Alabama
- Effluent hold tank residence time - 4.1 minutes versus 12 minutes
- Effluent hold tank configuration - single tank versus 3 tanks in series

A summary of the pertinent results and the major test conditions is presented in Table 4-3. For the variables evaluated in this test series, the fineness of grind had the greatest effect on SO_2 removal efficiency. Effluent hold tank residence time, limestone type, and effluent hold tank configuration all had lesser effects.

A more extensive limestone type and grind testing program is currently scheduled in the Shawnee Advanced Program.

Table 4-2

ANALYSES OF LIMESTONES USED IN THE TEST SERIES

Bahco Analysis	Fredonia Fine	Fredonia Coarse	Longview Coarse
Micron Size	% Less Than	% Less Than	% Less Than
3	39.5	21.1	16.1
6	57.9	33.4	26.8
9	67.8	38.4	34.4
12	73.8	43.6	40.0
16.5	80.0	49.4	47.0
22	84.7	54.8	48.0
27	87.6	58.6	57.4
30	88.9	60.4	59.2
Screen Analysis			
Mesh Size	% Less Than	% Less Than	% Less Than
400	93.1	64.6	61.7
325	95.9	69.1	64.8
200	99.3	80.8	74.6
100	99.4	81.0	74.8
50	100.0	99.9	99.3
30	100.0	100.0	100.0
Number of Samples	2	6	2
Chemical Analysis			
CaO	54.14%	53.18%	54.23%
MgO	0.48	0.74	0.66
CO_2	39.56	39.54	39.99
Acid insolubles	2.18	2.27	1.27
Number of Samples	6	11	4

Table 4-3

SUMMARY OF TCA LIMESTONE TYPE AND GRIND TESTS
(With high fly ash loading, no MgO addition)

Major Test Conditions[1]	707-2A	708-2A	709-2A	710-2A	711-2A	712-2A
Limestone type	Fredonia	Fredonia	Longview	Fredonia	Fredonia	Fredonia
Average grind, wt% <325 mesh	96	69	65	69	96	96
Gas rate, acfm @ 300°F	30,000	30,000	30,000	30,000	30,000	30,000
Liquor rate, gpm	1200	1200	1200	1200	1200	1200
Percent solids recirculated	15	15	15	15	15	15
Effluent residence time, min.	4.1	4.1	4.1	12	12	12 (3 tanks)
Limestone stoichiometric ratio (controlled)	1.2	1.2	1.2	1.2	1.2	1.2
Selected Results						
Scrubber inlet pH	5.6	5.2	5.3	5.4	5.65	5.85
Stoichiometric ratio	1.23	1.15	1.18	1.21	1.25	1.21
Percent SO_2 removal	72	49	55	54	64	69
Inlet SO_2 concentration, ppm	3100	3100	3350	3400	3250	3050
SO_2 make-per-pass, m-mol/liter	11.5	8.0	9.5	9.5	11.0	11.5
Inlet liquor % gypsum saturation @ 50°C	100	115	110	110	80	60
Percent sulfite oxidation	17	14	20	16	15	18
Onstream hours	113	128	56(2)	162	93	117

Notes:

(1) Clarifier only used for solids dewatering in all runs.
(2) Run 709-2A was terminated prematurely due to severe limestone feed line plugging problems.

4.5 LABORATORY LIMESTONE REACTIVITY TEST RESULTS

Laboratory tests of limestone reactivity were conducted at Shawnee to study the effect of limestone source and grind on reactivity. Detailed results of these tests have been reported earlier in Section 19 of Reference 5. During this test series, limestones from eleven different quarries were evaluated. Table 4-4 lists their chemical compositions and the degree of grinding.

Two methods were used to determine reactivity:

(1) HCl method - 5 grams of dried limestone powder were added to an agitated 300 ml solution of HCl at pH 3 and 25°C and the rise of pH with time was recorded.

(2) SO_2 method - First 0.2 mole of limestone was dissolved in two liters of distilled water at 50°C until a constant pH was reached. Then a constant stream (0.273 g-mole/hr) of pure SO_2 gas was bubbled through the slurry and the pH drop with time was monitored.

As expected, for a given limestone the reactivity improved with increased grinding. However, the relative benefits of grinding varied among the limestones. In general, the denser (low porosity and/or small pore size) the limestone, the stronger the dependence of reactivity on particle size (grinding). Similar behavior was also observed during the limestone type and grind tests at Shawnee (see Section 4.4).

Some conflicting results were obtained when comparing reactivies obtained by the two methods. The SO_2 method, although somewhat more involved than the HCl method, was judged to be more appropriate for evaluating reactivity because it more closely simulated the environment existing in SO_2 wet-scrubbing processes.

Table 4-4

LIMESTONES USED IN REACTIVITY TESTS

Limestone Source	Location	Chemical Composition, wt percent				Grind, percent less than	
		Calcium (Ca)	Magnesium (Mg)	Carbonate (CO_3)	Acid Insolubles	-200 Mesh	-325 Mesh
Citadel Stone Company	Selma, Alabama	32.5	0.2	47.4	14.8	94	93
Commonwealth Edison	Joliet, Illinois	37.9	1.4	56.6	3.5	65	78
Cowan Stone Company	Cowan, Tennessee	36.0	1.5	55.9	4.0	80	91
Fredonia Quarries	Fredonia, Kentucky	35.8	2.5	60.5	2.2	75	90
Georgia Marble	Sylacauga, Alabama	38.8	0.5	59.2	2.0	71	78
Hoover Incorporated	Nashville, Tennessee	36.6	1.2	54.1	3.8	92	84
Longview Lime Company	Longview, Alabama	38.2	0.7	59.9	1.0	72	77
Luttrell Mining Company	Knoxville, Tennessee	38.8	0.2	58.4	1.4	77	82
Rigsby & Barnard Quarry	Cave In Rock, Illinois	38.4	0.2	57.8	0.4	69	90
The Stone Man	Chattanooga, Tennessee	36.4	1.0	57.2	4.1	72	78
Vulcan Material Company	Knoxville, Tennessee	38.1	1.1	60.2	0.5	97	95

Additional tests have been planned for both the EPA-IERL pilot plant and the Shawnee Test Facility to study the relationships among the SO_2 removal, pH, and stoichiometry for different limestone types and grinds.

4.6 AUTOMATIC LIMESTONE FEED CONTROL

The feasibility of automatic alkali feed control in a limestone wet-scrubbing system was investigated at Shawnee (Reference 5, Section 11). The incentives for automatic limestone feed control were:

- Minimizing limestone required to meet an SO_2 emission target of 1.2 lbs/MM Btu
- Reducing manual operation and operator errors
- Improving scrubber reliability

The control scheme tested at Shawnee was based on the material balance concept. In this scheme, a desired stoichiometric limestone feed was maintained in relation to the amount of SO_2 entering or absorbed in the scrubber according to the following equation:

Limestone (60 percent slurry) addition rate, gpm

$$= G \times (SO_2I - K_{out}) \times K_{SR}$$

where: G = flue gas rate, acfm @ 300°F

SO_2I = inlet SO_2 concentration measured by Du Pont analyzer, ppm

K_{out} = a manually adjustable constant related to desired outlet SO_2 concentration, ppm

K_{SR} = a manually adjustable constant proportional to the stoichiometric ratio

= (unit conversion factor) x (stoichiometric ratio)

= 2.34×10^{-8} x (stoichiometric ratio)

In practice, the gas rate, G, and inlet SO_2 concentration, SO_2I, vary within a wide range depending on the boiler load and the coal sulfur content. Therefore, the control scheme included the following overrides:

- If the outlet SO_2 concentration exceeded a set maximum, the limestone feed rate was stepped up to a preset maximum
- If the outlet SO_2 concentration dropped below a set minumum, the limestone feed rate was stepped down to a preset minum

The former provision minimized excursions beyond the SO_2 emission target, while the latter effected limestone savings by limiting unnecessary SO_2 removal.

The limited experience with this first-generation control design at Shawnee, although favorable, revealed several areas for improvement. One specific area that could be readily improved relates to the override control methods. These resulted in either under-feeding or over-feeding of limestone with resultant loss in scrubber performance and sometimes system scaling, respectively. A proposed modification would add a proportioning device to regulate the limestone feed rate, at the overriding conditions, in proportion to the difference between the outlet SO_2 setpoint and the prevailing SO_2 outlet concentration.

4.7 CONTROL OF LIMESTONE SYSTEMS

As in the case of lime scrubbing systems, two of the major parameters in limestone scrubbing are the concentrations of alkaline species in the scrubbing liquor (indicated by the pH in lime systems) and the weight percent concentration of solids in the recirculated slurry.

Unlike the lime systems, the pH of the recirculating slurry in limestone systems is a poor indicator of the alkalinity level because, in the operating pH range of 5.5 to 6.0, the limestone slurry is highly buffered. A more appropriate but harder to measure indicator is the stoichiometric ratio of calcium to sulfur in the mixed reactant and product solids. In practice, the stoichiometric ratio is controlled within narrow limits (see Section 4.6) with the pH used as the override because it is readily measured.

Unlike lime systems, the suspended limestone solids concentration in the slurry has a significant effect on the pH and SO_2 removal because limestone dissolves less readily than lime. This is especially true at slurry solids concentrations below about 7 percent, excluding fly ash (see Section 4.2.3). At a constant limestone addition rate lower slurry solids concentration yields low pH because less limestone dissolution occurs per unit time.

Unlike the lime system, the limestone system is buffered, and thus its response to abrupt changes in inlet SO_2 concentrations is sluggish. For example, it is possible that, if the inlet SO_2 concentration drops abruptly and significantly, high stoichiometric ratios can result owing to the large inventory of unused limestone in the system. This can result in severe scaling. Alternately, a sudden and significant rise in inlet SO_2 concentration may result in the degradation of SO_2 removal performance because of the lack of adequate limestone capacity. Under these conditions, a significant drop in pH may lead to bisulfite blinding (loss of reactivity) of the limestone particles, if the operator response is slow in raising the limestone feed rate.

The control of recirculated solids concentration, tank levels and the startup and shutdown considerations are similar to those for lime wet scrubbing systems (see Section 3.3).

A thorough study of the response of limestone wet scrubbing systems to abrupt changes in gas flow rate (liquid-to-gas ratio) and inlet SO_2 concentration level was made during two separate testing blocks. The first block was operated with natural oxidation and the second was conducted with two-loop forced oxidation. During the 747-hour natural oxidation test block (Reference 5, Section 13.3), the gas flow rate was varied between 20,000 and 30,000 acfm (at 300°F) and inlet SO_2 concentration ranged from 2200 to 3400 ppm. No problems due to the cycling gas rate and gas composition* were encountered since these changes were mostly within the operator and system response capabilities. The condition of the mist eliminator remained unchanged, with a 1 percent restriction of the total cross-sectional area by dust-like solids at the conclusion of test block. Some minor fall-out solids from the outlet duct and reheater above were found on the mist eliminator.

During the 840-hour two-loop forced-oxidation test block (Reference 5, Section 5.2.13), the gas flow rate was varied between 18,000 and 35,000 acfm (at 300°F) and inlet SO_2 concentration ranged from 2500 to 3400 ppm. Again, no problems due to cycling gas rate and gas composition were encountered.

The actual average SO_2 emissions were about 1.1 and 1.0 lb/MM Btu for the forced and natural oxidation test blocks, respectively. Thus the average SO_2 emissions for both were below the 30-day average of 1.2 lb/MM Btu.

SO_2 emissions varied overall from 0.4 to 1.8 lb/MM Btu. There were 10 periods greater than 24 hours during which the SO_2 emission exceeded 1.2

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* It should be noted that with the boiler operating philosophy at Shawnee, significant increase in flue gas oxygen concentration accompanies operation at low boiler load.

lb/MM Btu: six during the forced oxidation run and four during the natural oxidation run. There were about 25 other "spikes" lasting three hours or longer and divided almost equally between the two testing blocks.

Section 5

LIME/LIMESTONE SCRUBBING WITH MAGNESIUM ENHANCEMENT

In both lime and limestone wet scrubbing of SO_2, the concentration of dissolved species in the scrubber inlet liquor that can react with SO_2 in the flue gas is very low, about 1-2 m-mole/l. This is well below the SO_2 make-per-pass,* typically about 10 m-mole/l for Shawnee. Therefore, the SO_2 absorption rate is largely dependent upon the slow rate of limestone and $CaSO_3$ dissolution into the liquor passing through the scrubber.

Addition of an appropriate soluble magnesium compound, such as reactive MgO or $MgSO_4$, to the scrubbing liquor increases the concentration of dissolved sulfite species, $MgSO_3^{\circ}$ and $SO_3^{=}$, thus making the SO_2 absorption rate more dependent on the fast liquid-phase base-acid reactions of these sulfite species with SO_2 (aq):

$$\text{base} + \text{dibasic acid} \longrightarrow \text{monobasic acid} \qquad (5\text{-}1)$$

$$MgSO_3^{\circ} + SO_2\,(aq) + H_2O \longrightarrow 2HSO_3^{-} + Mg^{++} \qquad (5\text{-}2)$$

$$SO_3^{=} + SO_2\,(aq) + H_2O \longrightarrow 2HSO_3^{-} \qquad (5\text{-}3)$$

---

* Defined as milligram-moles of SO_2 absorbed from the flue gas per liter of liquor as the recirculated slurry makes one pass through the scrubber.

Conversion of SO_2 (aq) to HSO_3^- by the above reactions in the scrubber encourages the absorption of more SO_2 (g) into the liquor as SO_2 (aq), thus increasing SO_2 removal.

About 200-400 m-mole/l (5000-10,000 ppm) of dissolved magnesium associated with sulfite and sulfate (magnesium chloride, $MgCl_2$, has little effect on SO_2 removal) are required to provide a concentration of dissolved sulfite species equal to the SO_2 make-per-pass. High SO_2 removal was generally achieved under this condition for the Shawnee spray tower and TCA. The quantitative effect of magnesium addition on SO_2 removal for these scrubbers with lime and limestone is discussed in Section 7.

5.1 EFFECT OF MAGNESIUM ADDITIVE ON DISSOLVED SULFITE SPECIES

The concentration of dissolved sulfite species increases with magnesium addition. Dissolution of MgO into a lime/limestone wet scrubbing liquor provides Mg^{++} ion, thus greatly increasing the total cation concentration (dissolved calcium species are only about 20 m-mole/l for calcium sulfite/sulfate liquors). To maintain electroneutrality additional anions must go into solution. Therefore the concentrations of dissolved SO_2 and sulfate increase as ionic sulfite, bisulfite and sulfate ($SO_3^=$, HSO_3^-, and $SO_4^=$) increase with increasing magnesium. The concentration of the ion pair of magnesium and sulfite, $MgSO_3^o$, which is the major dissolved sulfite species with magnesium additive, also increases with both Mg^{++} and $SO_3^=$. This increase in dissolved sulfite species, $SO_3^=$ and $MgSO_3^o$, which are basic to SO_2(aq), increases SO_2 removal.*

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* The concentration of $CaSO_3^o$, which is also basic to (SO_2)aq, is essentially constant for liquors saturated with calcium sulfite.

5.2 IMPORTANCE OF CALCIUM SOLIDS EQUILIBRIA

The importance of dissolved calcium is that the solubility products and relative saturations of calcium sulfite ($CaSO_3 \cdot 1/2H_2O$) and gypsum ($CaSO_4 \cdot 2H_2O$) determine the concentration ratio of sulfite ion to sulfate ion, $[SO_3^=]/[SO_4^=]$, in the scrubbing liquor. The ionic species in the liquor are related to the solubility products and relative saturations by:

$$(Ca^{++})(SO_3^=) = K_1 RS_1 \tag{5-4}$$

$$(Ca^{++})(SO_4^=) = K_2 RS_2 \tag{5-5}$$

where:

(Ca^{++}), $(SO_3^=)$, $(SO_4^=)$ = activities of dissolved Ca^{++}, $SO_3^=$, and $SO_4^=$ ions, respectively, g-mole/l.

K_1 = solubility product for calcium sulfite, about 3.5×10^{-7} $(g\text{-mole}/l)^2$ at 50°C.*

K_2 = solubility product for gypsum = 2.2×10^{-5} $(g\text{-mole}/l)^2$ at 50°C.

RS_1, RS_2 = relative saturations of liquor with calcium sulfite and gypsum, respectively.

= 1 if liquor is in equilibrium with the corresponding solid.

Scrubber inlet liquors are assumed to be saturated with calcium sulfite ($RS_1 = 1$). Also, the activity coefficients of $SO_3^=$ and $SO_4^=$ are assumed equal as a first approximation. Under these conditions Equations 5-4 and 5-5 can be combined to give:

$$[SO_3^=]/[SO_4^=] = \frac{K_1}{K_2\ RS_2} \tag{5-6}$$

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* This value is a calculated average for Shawnee scrubber inlet liquors, and may include kinetic, as well as thermodynamic, effects in lime/limestone wet scrubbing.

At 50°C, the ratio $[SO_3^=]/[SO_4^=]$ is about $1/(60\ RS_2)$.

From Equation 5-6 it is apparent that:

- Magnesium can be added as solid MgO, as $MgSO_4$ solid or solution, or even as $Mg(HSO_3)_2$ solution. For any of these cases, the calcium solids equilibria will establish the concentration of $SO_3^=$ in accordance with Equation 5-6, and the concentration of $MgSO_3^o$ in accordance with the equilibrium among Mg^{++}, $SO_3^=$, and $MgSO_3^o$.
- For operation with gypsum-unsaturated liquor ($RS_2 < 1$, low sulfite oxidation with co-precipitation of calcium sulfate as an impurity in calcium sulfite), the concentration of dissolved sulfite species is higher than for gypsum-saturated operation. Thus, SO_2 removal should increase as the degree of gypsum saturation in the liquor decreases.

5.3 EFFECTIVENESS OF MAGNESIUM IN THE PRESENCE OF CHLORIDE

As noted previously, the primary objective of magnesium addition is to dissolve more anions that are basic to SO_2 (aq), thus increasing SO_2 removal. However, when chloride is introduced into the scrubber liquor, by absorption of HCl, the effectiveness of magnesium is reduced because HCl is a stronger acid than SO_2 (aq).*

Because chloride does not react with SO_2, it is convenient to describe the reactivity of a magnesia enhanced scrubbing liquor (containing calcium-based slurry solids) in terms of the dissolved magnesium sulfite/sulfate concentration, referred to as the effective magnesium concentration $[Mg^{++}]_E$:

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* This detrimental effect of the anion of a strong acid is mitigated for sulfate, because of the low solubility of calcium sulfate.

$$[Mg^{++}]_E = [Mg^{++}]_{total} - (1/2)[Cl^-] \qquad (5\text{-}7)$$

where:

$[Mg^{++}]_E$ = effective magnesium concentration, g-mole/l

$[Mg^{++}]_{total}$ = total concentration of dissolved magnesium species, g-mole/l

$[Cl^-]$ = concentration of dissolved chloride species, g-mole/l

The usefulness of effective magnesium as a control variable for magnesium enhanced lime/limestone systems is apparent from the linear relationship between dissolved sulfite and effective magnesium, and the near independence of this relationship on chloride concentration. Figure 5-1 indicates that, for scrubbing liquors saturated with gypsum and calcium sulfite, effective magnesium should correlate with SO_2 removal about as well as dissolved sulfite does. This was indeed the case for Shawnee data. Effective magnesium as a dependent variable successfully expressed the beneficial effect of magnesium additive on SO_2 removal (see Section 7).

5.4 pH INDEPENDENCE OF DISSOLVED SULFITE CONCENTRATIONS

As shown in Figure 5-2, the concentration of dissolved sulfite species ($SO_3^=$, $CaSO_3^0$, and $MgSO_3^0$) in liquors saturated with calcium sulfite and gypsum is nearly independent of liquor pH. This implies that the dissolved sulfite concentrations for saturated scrubber inlet liquors, at the same effective magnesium concentration, will virtually be the same for lime (high pH) and limestone (low pH) liquors.

This lack of dependence of dissolved sulfite on pH can be explained by

FIGURE 5-1.

CONCENTRATION OF DISSOLVED SULFITE SPECIES ($SO_3^=$, Mg_3^O, AND $CaSO_3^O$) AS A FUNCTION OF EFFECTIVE MAGNESIUM CONCENTRATION (Mg - Cl/2)

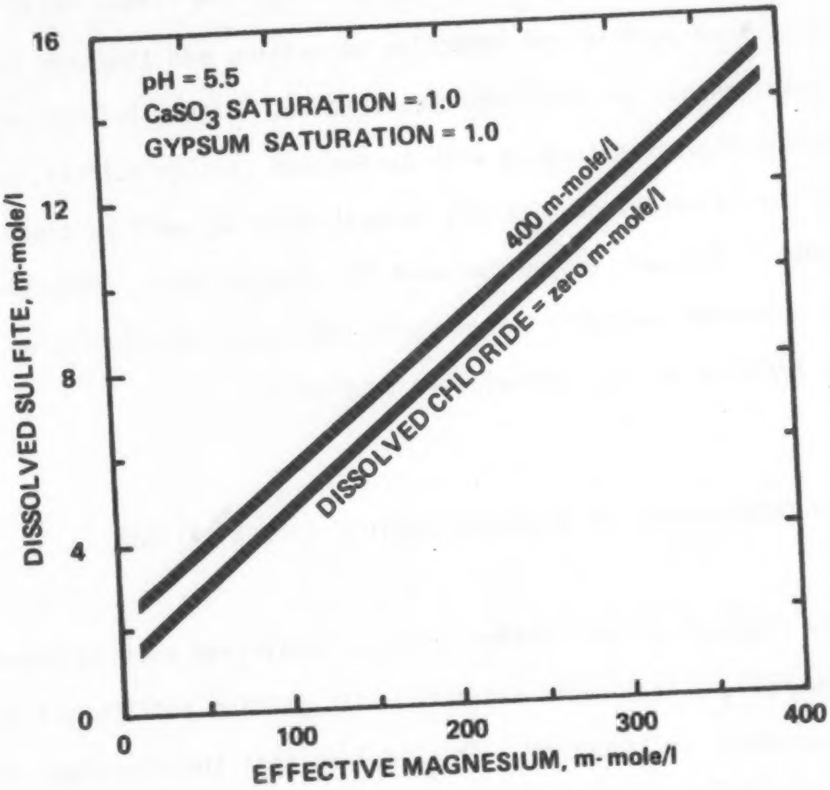
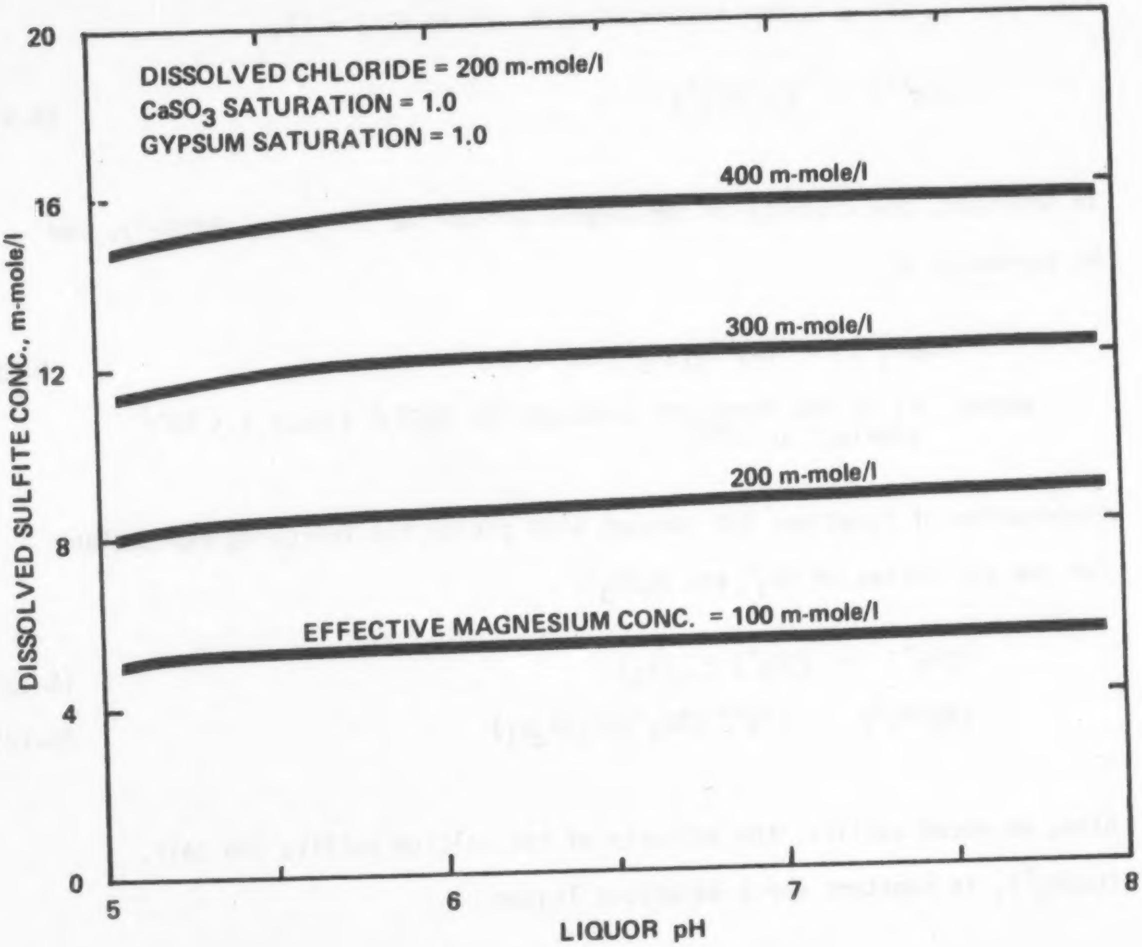


FIGURE 5-2.

INDEPENDENCE OF DISSOLVED SULFITE CONCENTRATION ($SO_3^=$, Mg_3^o, AND Ca_3^o) AND LIQUOR pH AT VARIOUS CONCENTRATIONS OF EFFECTIVE MAGNESIUM (Mg–Cl/2)



consideration of the equilibria involved. For a liquor saturated with calcium sulfite ($RS_1 = 1$), Equation 5-4 can be rearranged and the activity of sulfite ion, ($SO_3^=$), can be calculated as follows:

$$(SO_3^=) = K_1/(Ca^{++}) \tag{5-8}$$

Similarly, Equation 5-5 can be rewritten to obtain the activity of calcium ion, (Ca^{++}), for a liquor saturated with gypsum ($RS_2 = 1$);

$$(Ca^{++}) = K_2/(SO_4^=) \tag{5-9}$$

In addition, the activity of the magnesium sulfite ion pair, ($MgSO_3^o$), can be expressed as:

$$(MgSO_3^o) = (Mg^{++})(SO_3^=)/k_1 \tag{5-10}$$

where: k_1 is the formation constant for $MgSO_3^o$ (about 1×10^{-3} g-mole/l at 50°C).

Combination of Equations 5-8 through 5-10 yields the following expressions for the activities of $SO_3^=$ and $MgSO_3^o$:

$$(SO_3^=) = (SO_4^=)(K_1/K_2) \tag{5-11}$$

$$(MgSO_3^o) = (Mg^{++})(SO_4^=)(K_1/K_2k_1) \tag{5-12}$$

Also, as noted earlier, the activity of the calcium sulfite ion pair, ($CaSO_3^o$), is constant for a saturated liquor:

$$(CaSO_3^o) = (Ca^{++})(SO_3^=)/k_2 = K_1/k_2 = \text{constant} \tag{5-13}$$

where: k_2 is the formation constant for $CaSO_3^o$ (about 3×10^{-4} g-mole/l at 50°C).

Equations 5-11 through 5-13 demonstrate that the concentrations of the dissolved sulfite species are dependent only upon the concentrations of Mg^{++} and $SO_4^{=}$ ions and the activity coefficients of the various dissolved species, not upon the pH. Furthermore, the concentrations of Mg^{++} and $SO_4^{=}$ ions are determined by the total dissolved magnesium concentration (in the absence of chloride), and are independent of pH, because sulfuric acid is too strong an acid to allow significant formation of bisulfate ion, HSO_4^{-}.* The activity coefficients are dependent only upon the ionic strength which is primarily determined by the Mg^{++} and $SO_4^{=}$ concentration for these systems.

Therefore, the ionic equilibria demonstrate that pH independence of dissolved sulfite concentration is a good approximation for saturated liquors. This is also true for liquors having the same relative calcium sulfite and gypsum saturations, even when the individual relative saturation values are not equal to one.

5.5 LIME/LIMESTONE TESTS WITH MAGNESIUM ENHANCEMENT

This subsection discusses only test results for the most recent lime and limestone tests with magnesium additive and no forced oxidation (Sections 16 and 17, Reference 5). Test results for forced oxidation and factorial runs with magnesium are summarized in Sections 6 and 7, respectively.

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* Concentrations of calcium, sulfite, and bisulfite species are relatively low, so that the concentrations of Mg^{++} and $SO_4^{=}$ ions are nearly equal.

5.5.1 Limestone Test Runs

Six limestone runs were made, including two base case runs without magnesium oxide and four runs with magnesium oxide addition. Flue gas with high fly ash loading was used in all runs. Table 5-1 presents the major test conditions and important test results.

Because of coal shortage caused by the coal miners' strike in the first quarter of 1978, coals from different sources were burned in Boiler No. 10. As a result, inlet SO_2 concentration fluctuated as much as tenfold (320 to 3400 ppm) and the run-average concentrations were considerably lower than normal in most of the runs. These wide variations in inlet SO_2 concentration not only created process control problems, but also caused some difficulties in the interpretation of run data and in the run-to-run comparision of test results.

Comparison of data from runs with and without magnesium oxide addition indicated that at a 5000 ppm effective Mg^{++} concentration, SO_2 removal increased to 92 percent from 77 percent without magnesium oxide addition, at an inlet SO_2 concentration of about 2400 ppm. At 9000 ppm effective Mg^{++} concentration, average SO_2 removal was 93 to 95 percent at a higher inlet SO_2 concentration of 2850 ppm.

In summary, magnesium-enhanced limestone testing indicated:

- Even though limestone and lime scrubbing liquors have similar dissolved sulfite concentrations, higher effective Mg^{++} concentration is required in a limestone system than in a lime system to obtain similar improvement in SO_2 removal (see Section 7). This may be due to the lower pH in the limestone system, where the shift towards bisulfite reduces SO_2 removal efficiency.

Table 5-1

SUMMARY OF LIMESTONE TESTS WITH MgO ADDITION ON THE TCA SYSTEM

Major Test Conditions(1)	590-2A	590-2B	591-2A	592-2A	593-2A	594-2A
MgO addition	No	No	Yes	Yes	Yes	Yes
Fly ash loading	High	High	High	High	High	High
Gas rate, acfm @ 300°F	30,000	30,000	30,000	30,000	30,000	30,000
Slurry flow rate to TCA, gpm	1200	1200	1200	1200	900	1200
Percent solids recirculated	15	15	15	15	15	15
EHT residence time, min(2)	4.1	4.1	4.1	4.1	4.1	4.1
EHT level, ft(2)	17	17	17	17	12.8	17
Downcomer to EHT(2)	Ext.	Int.	Ext.	Ext.	Ext.	Int.
Limestone stoichiometric ratio (controlled)	1.2	1.2	1.2	1.2	1.2	1.2
Limestone addition point(3)	DC	DC	EHT	EHT	EHT	EHT
Effective Mg^{++} concentration, ppm	0	0	5000	9000	9000	9000
Selected Results						
Percent SO_2 removal	64	77	92	95	93	93
Inlet SO_2 concentration,ppm	2100	2450	2300	2850	2850	2850
SO_2 make-per-pass, m-moles/liter	7.3	9.9	11.3	13.8	18.8	13.8
TCA inlet liquor sulfite concentration, ppm(4)	770	270	2000	4360	4855	5370
TCA inlet liquor gypsum saturation, %	110	120	105	105	85	90
Percent sulfite oxidation	45(5)	31	43	25	24	18
Percent limestone utilization	88	85	80	74	63	81
TCA inlet pH	5.0	5.3	5.5	5.4	5.45	5.35
Effective Mg^{++} concentration, ppm	0	0	4930	8870	9000	8950
Onstream hours	45	92	207	293	260	99

Notes:

(1) All runs were made with 3 beds (4 grids) and with nominally 5 inches/bed of 1 5/8 inch diameter nitrile foam spheres. Clarifier and centrifuge were used for solids dewatering in all runs.

(2) The effluent hold tank (D-204) was 7 ft in diameter and 21 ft high. Tests were made with either an internal or external downcomer.

(3) EHT or downcomer (DC).

(4) Total sulfite includes $SO_3^=$ and HSO_3^-.

(5) Steady-state sulfite oxidation was not reached during Run 590-2A.

- Under typical operating conditions, SO_2 removal improved by about 15 percentage points with 9000 ppm effective Mg^{++} concentration.

- At the magnesium levels tested the scrubber inlet liquors were approximately saturated with gypsum.

- Gypsum saturation tended to be higher at lower SO_2 make-per-pass and higher sulfite oxidation.

- Generally, a higher oxygen/sulfur dioxide ratio in the scrubber inlet gas resulted in higher sulfite oxidation.

5.5.2 Lime Test Runs

Nine lime runs were made, including two base case runs without magnesium oxide addition and seven runs with 2000 ppm effective Mg^{++} concentration. Flue gas with high fly ash loadings was used. Major test conditions and important test results are summarized in Table 5-2.

As noted earlier, coals from several different sources were burned in the first quarter of 1978. Inlet SO_2 concentration fluctuated as much as tenfold (320 to 3400 ppm) and the run-average concentrations were significantly lower than normal during most of the runs. The wide variations in inlet SO_2 concentration created process control problems and caused difficulties in the data interpretation and in the run-to-run comparison of test results.

In summary, magnesium-enhanced lime testing indicated:

- At the high SO_2 removals (90-96 percent) and low inlet SO_2 concentrations (1600-2100 ppm) for these tests. no improvement in removal was observed with 2000 ppm effective Mg^{++} concentration. Overall reaction rate may be controlled by the gas phase mass transfer at these conditions.

- Lower inlet SO_2 concentrations resulted in sulfite oxidations 10 to 15 percentage points higher than normal, probably because of the higher O_2/SO_2 ratio in the inlet flue gas.

Table 5-2

SUMMARY OF LIME TESTS WITH MgO ADDITION ON THE TCA SYSTEM

Major Test Conditions[(1)]	618-2A	618-2B	619-2A	620-2A	621-2A	622-2A	622-2B	623-2A	624-2A
MgO addition	No	No	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fly ash loading	High	High	High	High	High	High	High	High	High
Gas rate, acfm @ 300°F	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
Slurry flow rate to TCA, gpm	1200	1200	1200	900	1200	900	900	1200	900
Percent solids recirculated	8	8	8	8	8	8	8	8	8
EHT residence time, min(2)	4.1	4.1	4.1	4.1	3.0	4.1	4.1	3.0	3.0
EHT level, ft(2)	17	17	17	12.8	12.5	12.8	12.8	12.5	9.4
Downcomer to EHT(2)	Int.	Ext.	Ext.	Ext.	Ext.	Ext.	Ext.	Ext.	Ext.
TCA inlet pH (controlled)	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0	7.0
Lime addition point(3)	DC	DC	DC	DC	DC	EHT	DC	DC	DC
Effective Mg^{++} concentration, ppm	0	0	2000	2000	2000	2000	2000	2000	2000
Selected Results									
Percent SO_2 removal	90	96	94	91	96	92	85	91	82
Inlet SO_2 concentration, ppm	2100	1900	1850	1600	1950	2600	2600	2550	2900
SO_2 make-per-pass, m-moles/liter	10.2	8.9	9.2	10.3	10.3	16.4	15.0	12.3	16.4
TCA inlet liquor sulfite concentration, ppm(4)	85	80	355	330	310	940(5)	465	410	480
TCA inlet liquor gypsum saturation, %	120	120	90	95	105	95	95	70	65
Percent sulfite oxidation	28	30	23	27	29	22	14	14	15
Percent lime utilization	93	94	98	97	98	99	96	94	99
Effective Mg^{++} concentration, ppm	0	0	2360	2090	2135	4510(5)	2150	2190	1950
Onstream hours	162	88	306	106	239	91	125	271	269

Notes:

(1) All runs were made with 3 beds (4 grids) and with nominally 5 inches/bed of 1-5/8 inch diameter nitrile foam spheres. Clarifier and centrifuge were used for solids dewatering in all runs except Run 624-2A in which clarifier only was used.

(2) The effluent hold tank (D-204) was 7 ft in diameter and 21 ft high. Tests were made with either an internal or external downcomer.

(3) EHT or downcomer(DC).

(4) Total sulfite includes $SO_3^=$ and HSO_3^-.

(5) Steady-state concentrations were not reached for Run 622-2A from a previous high magnesium limestone run.

- Within the range of low hold tank residence times tested (3.0 to 4.1 minutes), lower residence time resulted in lower saturation at similar sulfite oxidation level (Run 622-2B vs. 624-2A).

- Generally, magnesium addition reduced gypsum saturation (from about 120 to 95 percent), perhaps because of somewhat higher SO_2 make-per-pass and slightly lower sulfite oxidation.

Section 6

FORCED OXIDATION

This section presents the results of testing at the Shawnee Test Facility to develop commercially feasible forced-oxidation procedures for reducing the volume and improving the disposal characteristics of the waste solids product (Reference 5).

The waste solids consist primarily of calcium sulfite, calcium sulfate (gypsum), and fly ash. The relative amounts of sulfite and sulfate depend on the degree of oxidation in the scrubbing system. In most medium-to-high sulfur coal applications, natural oxidation of sulfite to sulfate in the scrubber system amounts to only 10 to 30 percent and calcium sulfite is the predominant material in the waste sludge.

Calcium sulfite wastes present a serious disposal problem because of the difficulty of dewatering. The slurry can be dewatered only to about 50 to 60 percent solids, producing an unstable, thixotropic material unsuitable for landfill. Where space is available, ponding of the untreated sulfite sludge has been practiced. However, the pond area may be impossible to reclaim, and in many locations sufficient space is not available.

Preliminary economic evaluations by TVA (Reference 14) have shown that forced oxidation is a more economical method of producing landfill materials than other methods such as commercial fixation of sulfite sludge with additives and blending sulfite sludge with fly ash.

Beginning in 1976, studies conducted by EPA with the 0.1-MW pilot plant (Reference 15), showed that calcium sulfite could be readily oxidized to gypsum by simple air/slurry contact in the hold tank of the scrubber recirculation loop. Although the rate of oxidation reached a maximum at a pH of 4.5 and then declined at higher pH, it was found that oxidation could be accomplished at a practical rate up to a pH of about 6.0.

Based on the findings at the pilot plant, a program was set up at the Shawnee Test Facility to develop procedures for forced oxidation. Forced oxidation testing was initiated in January 1977 and continued throughout the Shawnee Advanced Test Program.

Systems successfully demonstrated were:

- Forced oxidation in the first of two scrubber loops using lime slurry, limestone slurry, and limestone slurry with added magnesium oxide
- Forced oxidation within a single scrubber loop using limestone slurry
- Forced oxidation of a scrubber bleed stream using limestone slurry with added magnesium oxide

6.1 FORCED OXIDATION WITH TWO SCRUBBER LOOPS ON THE VENTURI/SPRAY TOWER SYSTEM

6.1.1 System Description

Forced oxidation with two scrubber loops in series was successfully demonstrated in the venturi/spray tower system with three alkali types: limestone, lime, and limestone with added magnesium oxide. In this arrangement (Figure 6-1), the flue gas passed through two scrubbers in series, each with its own hold tank and slurry recirculation loop. The first loop was operated at a relatively low pH to provide favorable conditions for forced oxidation while the second loop was operated at a higher pH for good SO_2 removal.

The hold tank in the first scrubber (venturi) recirculation loop was used as the oxidation tank. The arrangement of this tank is shown in Figure 6-2. The tank was 8 ft in diameter and could be operated at 10, 14, or 18-ft slurry levels. In early tests the tank contained an air sparger ring made of straight 3-inch 316L SS pipe pieces welded into an octagon approximately 4 ft in diameter. It was located 6 inches from the bottom of the tank. Sparger rings had either 130 1/8-inch diameter holes or 40 1/4-inch diameter holes, pointing downward. The sparger ring was fed with compressed air to which sufficient water was added to assure humidification. In later tests the sparger ring was replaced by a 3-inch diameter pipe with an open elbow discharging air downward at the center of the tank about 3 inches from the tank bottom.

The oxidation tank had an agitator with two axial flow turbines, both pumping downward. Each turbine was 52 inches in diameter and contained 4 blades. The bottom turbine was 10 inches above the air sparger. The agitator rotated at

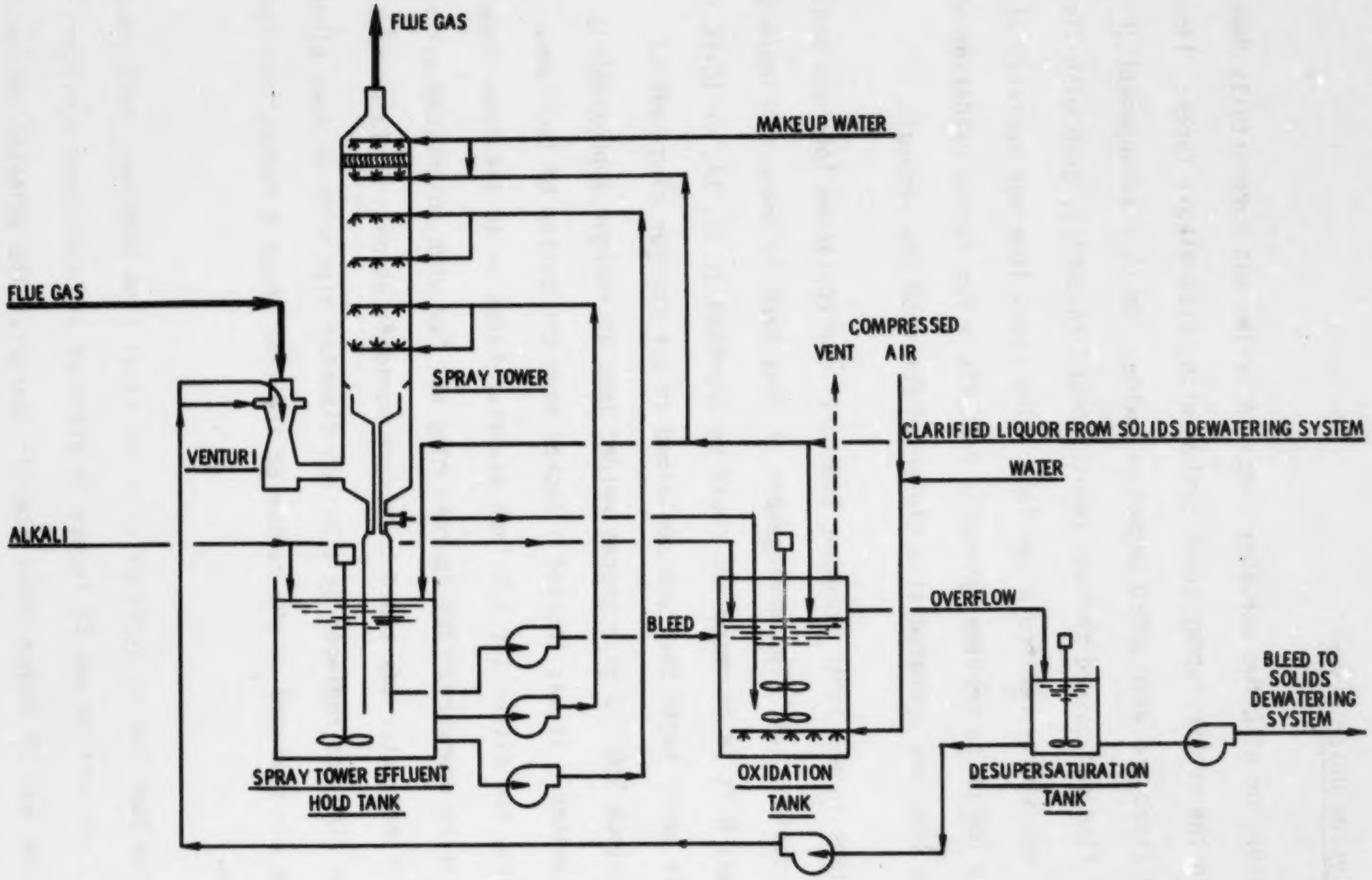
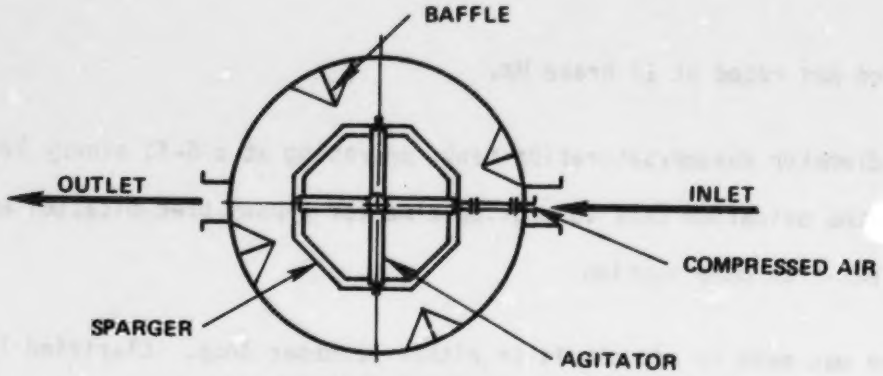
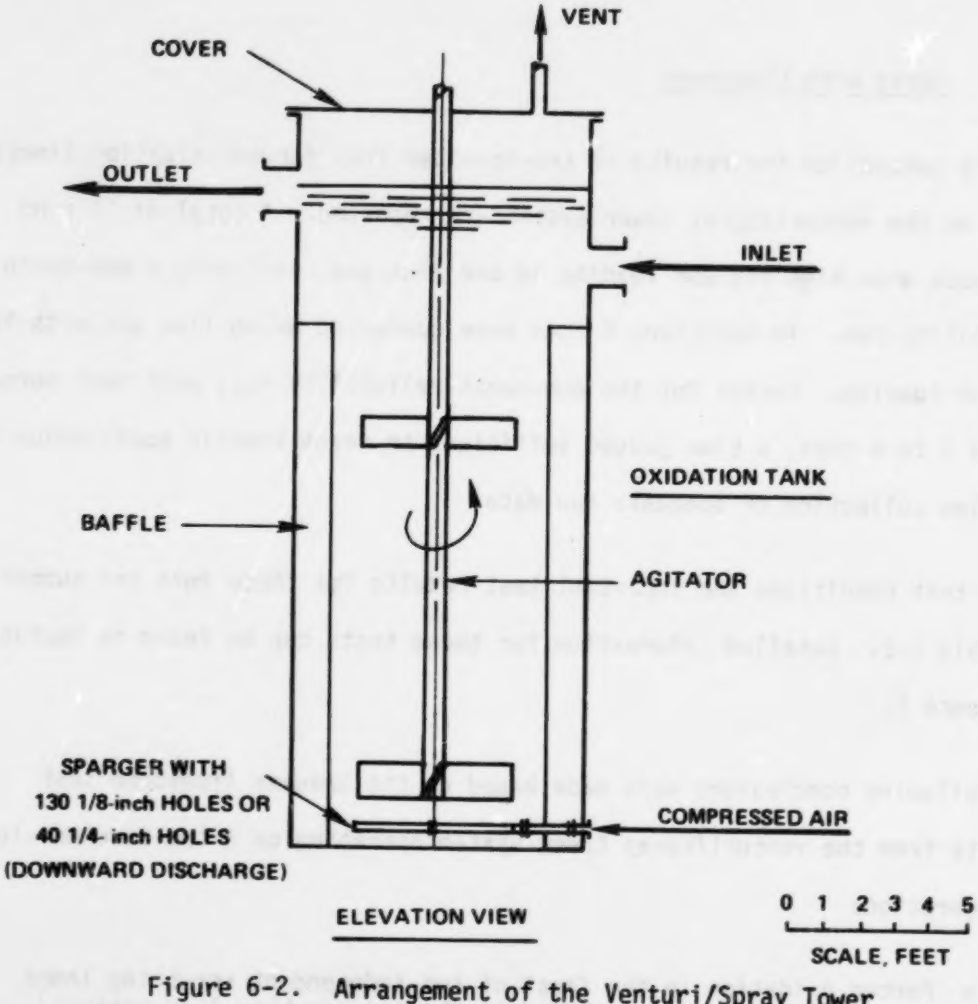

FLUE GAS
MAKEUP WATER
FLUE GAS
COMPRESSED
VENT
AIR
SPRAY TOWER
VENTURI
CLARIFIED LIQUOR FROM SOLIDS DEWATERING SYSTEM
WATER
ALKALI
OVERFLOW
BLEED
BLEED TO SOLIDS DEWATERING SYSTEM
SPRAY TOWER EFFLUENT HOLD TANK
OXIDATION TANK
DESUPERSATURATION TANK

Figure 6-1. FLOW DIAGRAM FOR TWO-SCRUBBER-LOOP FORCED-OXIDATION TESTS IN THE VENTURI/SPRAY TOWER SYSTEM


BAFFLE
OUTLET
INLET
COMPRESSED AIR
SPARGER
AGITATOR

OXIDATION TANK

PLAN VIEW


VENT
COVER
OUTLET
INLET
OXIDATION TANK
BAFFLE
AGITATOR
SPARGER WITH
130 1/8-inch HOLES OR
40 1/4- inch HOLES
(DOWNWARD DISCHARGE)
COMPRESSED AIR
0 1 2 3 4 5
SCALE, FEET

ELEVATION VIEW

Figure 6-2. Arrangement of the Venturi/Spray Tower Oxidation Tank with Sparger

56 rpm and was rated at 17 brake Hp.

A 10-ft diameter desupersaturation tank, operating at a 5-ft slurry level, followed the oxidation tank to provide time for gypsum precipitation and to provide air-free pump suction.

Provision was made to add alkali to either scrubber loop. Clarified liquor from the dewatering system could be returned to either scrubber loop or to the mist eliminator wash circuit.

6.1.2 Tests with Limestone

In this subsection the results of two-scrubber-loop forced-oxidation limestone tests on the venturi/spray tower system are reported. A total of 15 runs were made with high fly ash loading in the flue gas, including a one-month reliability run. In addition, 8 runs were conducted using flue gas with low fly ash loading. Except for the one-month reliability run, each test normally lasted 5 to 6 days, a time judged sufficient to reach kinetic equilibrium and to allow collection of adequate run data.

Major test conditions and important test results for these runs are summarized in Table 6-1. Detailed information for these tests can be found in Section 5, Reference 5.

The following conclusions were made based on the Shawnee limestone test results from the venturi/spray tower system operating on a two-scrubber-loop configuration:

- Forced oxidation in the first of two independent scrubbing loops was successfully demonstrated in the two-scrubber-loop venturi/spray tower system with limestone slurry. Successful demonstration was culminated with a one-month reliability limestone

Table 6-1

RESULTS OF FORCED-OXIDATION TESTS WITH TWO SCRUBBER LOOPS ON THE VENTURI/SPRAY TOWER SYSTEM USING LIMESTONE SLURRY

Major Test Conditions	801-1A	802-1A	803-1A	804-1A	805-1A	806-1A	806-1B	806-1C	806-1D
Fly ash loading	High	High	High	High	High	High	High	High	High
Gas rate, acfm @ 300°F	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000
Venturi liquor rate, gpm	400	400	600	600	600	600	600	600	600
Spray tower liquor rate, gpm	1300	1400	1400	1400	1400	1400	1400	1400	1400
Venturi percent solids recirculated (controlled)	15	15	15	15	15	15	15	15	15
Residence times, min: Oxidation tank[2]	17	17	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Desupersaturation tank	7	7	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Spray tower EHT	19.4	18	18	18	18	18	18	18	18
Venturi inlet (oxidation tank) pH (controlled)	4.5	5.0	5.0[3]	5.0	5.0	4.5	4.5	4.5	4.5
Venturi pressure drop, in. H_2O	9	9	9	9	9	9	9	9	9
Air rate to oxidation tank, scfm	400[4]	400[4]	400[4]	400[4]	400[4]	250[4]	150[4]	100[4]	50[4]
Clarified liquor returned to[7]	S.T	S.T	S.T	V. & S.T.	V.	V.	V.	V.	V.
Selected Results									
Percent SO_2 removal	62	60	67	71	78	73	74	73	80
Inlet SO_2 concentration, ppm	3400	3500	3150	3150	3450	3400	2850	3250	3100
Spray tower percent solids recirculated	5.8	6.1	5.4	7.4[8]	15.6	15.1	14.5	14.2	15.9
Spray tower inlet pH	5.7	5.5	5.65	5.8	6.15	6.15	6.1	6.0	6.15
Spray tower limestone stoichiometric ratio	1.20	1.37	1.47	1.45	1.53	1.30	1.25	1.25	1.35
Spray tower inlet liquor gypsum saturation, %	75	110	120	105	25	20	55	50	15
Spray tower sulfite oxidation, %	13	16	16	15	11	10	15	17	15
Overall sulfite oxidation, %	93	95	96	97	98	99	98	97	67
Overall limestone utilization, %	91	83	87	88	87	95	95	96	91
Venturi inlet liquor gypsum saturation, %	100	110	105	105	95	95	95	100	105
Venturi inlet liquor sulfite concentration, ppm	29	24	21	22	16	16	15	15	130
Air stoichiometry, atoms O/mole SO_2 absorbed	4.7	4.7	4.7	4.4	3.7	2.5	1.7	1.0	0.50
Filter cake solids, wt%[10]	81	86	81	85	81	84	82	79	79[11]
Onstream hours	263	256	138	151	112	45	45	54	41

Note: Footnotes for this table are listed at the end of Table 6-1 (continued)

Table 6-1 (continued)

RESULTS OF FORCED-OXIDATION TESTS WITH TWO SCRUBBER LOOPS ON THE VENTURI/SPRAY TOWER SYSTEM USING LIMESTONE SLURRY

	807-1A	808-1A	809-1A	810-1A	811-1A	812-1A	313 1A
Major Test Conditions							
Fly ash loading	High	High	Low	Low	Low	Low	Low
Gas rate, acfm @ 300°F	25,0-0	25,000	25,000	25,000	25,000	25,000	25,000
Venturi liquor rate, gpm	600	600	600	600	600	600	600
Spray tower liquor rate, gpm	1400	1400	1400	1400	1400	1400	1400
Venturi percent solids recirculated (controlled)	15	15	15	15	15	15	15
Residence times, min: Oxidation tank(2)	11.3	11.3	11.3	11.3	11.3	11.3	11.3
Desupersaturation tank	4.7	4.7	4.7	4.7	4.7	0	0
Spray tower EHT	18	18	13.4	13.4	13.4	13.4	13.4
Venturi inlet (oxidation tank) pH (controlled)	4.5	4.5	4.5	5.0	5.5	5.5	5.5
Venturi pressure drop, in. H_2O	9	9	9	9	9	9	9
Air rate to oxidation tank, scfm	0	150(4)	150(5)	150(5)	150(5)	150(5)	150(5)
Clarified liquor returned to(7)	V.	V.	S.T	S.T	S.T	S.T	S.T
Selected Results							
Percent SO_2 removal	79	76	82	83	85	93	
Inlet SO_2 concentration, ppm	3350	2850	2450	2700	2600	2350	
Spray tower percent solids recirculated	16.6	15.5	7.9	8.1	8.0	7.0	
Spray tower inlet pH	6.25	6.25	5.7	5.8	5.9	5.95	
Spray tower limestone stoichiometric ratio	1.34	1.20	1.30	1.35	1.40	1.93	
Spray tower inlet liquor gypsum saturation, %	8	23	105	105	105	100	
Spray tower sulfite oxidation, %	7	16	21	22	25	25	_(14)
Overall sulfite oxidation, %	18	97	98	98	97	98	
Overall limestone utilization, %	91	98	98	96	96	81	
Venturi inlet liquor gypsum saturation, %	135	100	95	95	105	105	
Venturi inlet liquor sulfite concentration, ppm	555	19	35	25	45	60	
Air stoichiometry, atoms O/mole SO_2 absorbed	0	1.7	1.85	1.65	1.65	1.70	
Filter cake solids, wt%(10)	74(11)	82(11)	80(12)	_(13)	_(13)	86	
Onstream hours	66	65	137	162	184	141	7

Table 6-1 (continued)

RESULTS OF FORCED-OXIDATION TESTS WITH TWO SCRUBBER LOOPS ON THE VENTURI/SPRAY TOWER SYSTEM USING LIMESTONE SLURRY

Major Test Conditions	814-1A	815-1A	816-1A	817-1A	818-1A	819-1A	819-1B
Fly ash loading	Low	Low	Low	High	High	High	High
Gas rate, acfm @ 300°F	25,000	35,000	35,000	35,000	35,000	$-^{(1)}$	$-^{(1)}$
Venturi liquor rate, gpm	600	600	600	600	600	600	600
Spray tower liquor rate, gpm	1400	1400	1400	1400	1600	1600	1600
Venturi percent solids recirculated (controlled)	15	15	15	15	15	15	15
Residence times, min: Oxidation tank$^{(2)}$	8.8	8.8	11.3	11.3	11.3	11.3	11.3
Desupersaturation tank	4.7	4.7	4.7	4.7	4.7	4.7	4.7
Spray tower EHT	13.4	13.4	13.4	16.8	14.7	14.7	14.7
Venturi inlet (oxidation tank) pH (controlled)	5.5	5.5	5.5	5.5	5.5	5.5	$-^{(9)}$
Venturi pressure drop, in. H_2O	9	9	9	9	7.5-9	≤9	≤9
Air rate to oxidation tank, scfm	$150^{(5)}$	$210^{(5)}$	$210^{(5)}$	$210^{(6)}$	$210^{(6)}$	$210^{(6)}$	$210^{(6)}$
Clarified liquor returned to$^{(7)}$	S.T	S.T	ST.	V.	V.	V.	V.
Selected Results							
Percent SO_2 removal	91	86	86	83	86	86	85
Inlet SO_2 concentration, ppm	2450	2500	2350	2500	2550	2950	3000
Spray tower percent solids recirculated	8.4	8.4	7.7	8.9	9.6	10	9.6
Spray tower inlet pH	5.95	5.85	5.75	5.9	5.9	5.85	5.9
Spray tower limestone stoichiometric ratio	1.78	1.98	1.68	1.60	1.64	1.65	1.65
Spray tower inlet liquor gypsum saturation, %	100	105	105	100	100	100	110
Spray tower sulfite oxidation, %	27	26	27	21	19	21	19
Overall sulfite oxidation, %	98	96	98	97	98	98	98
Overall limestone utilization, %	83	67	83	82	81	81	83
Venturi inlet liquor gypsum saturation, %	105	105	100	105	105	100	105
Venturi inlet liquor sulfite concentration, ppm	25	40	25	25	25	25	25
Air stoichiometry, atoms O/mole SO_2 absorbed	1.65	1.70	1.80	1.75	1.70	1.45-2.80	1.45-2.80
Filter cake solids, wt%$^{(10)}$	88	87	86	86	86	87	86
Onstream hours	136	306	142	188	141	840	126

Notes:

(1) Gas rate was varied from 18,000 to 35,000 acfm to follow the boiler load.
(2) Oxidation tank level was 18 ft for all runs except Runs 814-1A and 815-1A which were at 14 ft.
(3) Actual venturi inlet pH averaged 4.8.
(4) Used a sparger ring located 6 inches from tank bottom. The sparger ring had 130 1/8-inch holes on the bottom side.
(5) Used a sparger ring located 6 inches from tank bottom. The sparger ring had 40 1/4-inch holes on the bottom side.
(6) Air discharged downward through a 3-inch diameter pipe with an open elbow at center of oxidation tank about 3 inches from tank bottom.
(7) Spray tower loop (effluent hold tank) or venturi loop (oxidation tank).
(8) Controlled by proper flow split of clarified liquor returned to venturi and spray tower loops.
(9) Spray tower limestone stoichiometry controlled at 1.6.
(10) Clarifier and filter in series were used for solids dewatering in all runs except as noted.
(11) Values may not be representative due to changes in oxidation in short runs.
(12) Excludes last half of run when filter was out of service.
(13) Clarifier only was used.
(14) Test with oxidation tank agitator turned off. Terminated after 7 hours because the air sparging alone did not keep the solids suspended.

test using flue gas with high fly ash loading.

- Under the one-month reliability test conditions of 18,000 to 35,000 acfm gas rate, 600 gpm venturi slurry rate, 1600 gpm spray tower slurry rate, 15 percent venturi slurry solids concentration, 18 ft oxidation tank level, and 5.5 oxidation tank pH, 98 percent average sulfite oxidation was achieved at air stoichiometric ratios ranging from 1.4 to 2.8 atoms oxygen/mole SO_2 absorbed. The filter cake solids concentration averaged 87 percent.

- Ranges of conditions under which nearly complete sulfite oxidation (greater than 95 percent) was demonstrated were an oxidation tank pH of 4.5 to 5.5, oxidation tank level of at least 14 ft, and an air stoichiometric ratio of at least 1.5 atoms oxygen/mole SO_2 absorbed. Filter cake solids contents greater than 80 percent were consistently achieved under these conditions.

- Forced oxidation of the slurry within the scrubber loop dramatically improved the dewatering characteristics of the waste solids. Sulfite oxidation of 90 percent or higher was required for maximum improvement.

- Forced oxidation was achieved by simple air/slurry contact in the oxidation tank. Air/slurry contact efficiency did not appear to be affected, within the ranges of test conditions, whether an air sparger with 130 1/8-inch diameter holes, an air sparger with 40 1/4-inch diameter holes, or a 3-inch diameter open pipe was used. Air/slurry contact was primarily achieved by the two-turbine agitator operated at 56 rpm and rated at 17 brake Hp.

- Slurries with high or low fly ash loadings oxidized equally well.

- With forced oxidation, the venturi inlet slurry constantly exhibited a gypsum saturation of about 100 percent, which was below the incipient scaling level of 135 percent. This was undoubtedly caused by the abundance of gypsum crystal seeds produced by forced oxidation.

- Limestone utilization was improved with the two-scrubber-loop operation to at least 80 percent and as high as 98 percent, depending on the venturi inlet pH which averaged from 4.5 to 5.5. The venturi inlet pH was controlled by limestone addition to the spray tower hold tank.

- In limestone scrubbing, a low slurry solids concentration in the spray tower reduced the percent SO_2 removal. Furthermore, a solids concentration of 7 percent or higher was required to prevent calcium sulfite and sulfate scaling.

- Operation without the desupersaturation tank in the venturi slurry loop did not have an adverse effect on either sulfite oxidation or gypsum saturation in the venturi loop.

- Operation with the agitator turned off in the oxidation tank was not successful. Air sparging alone in the oxidation tank could not keep the solids from settling.

6.1.3 Tests with Limestone/MgO

Six runs were made during which magnesium oxide was added to the spray tower hold tank along with the limestone slurry. The primary purpose of the magnesium oxide addition was to enhance SO_2 removal efficiency in the spray tower loop by increasing the dissolved sulfite ion concentration for SO_2 scrubbing. In a two-scrubber-loop configuration, the magnesium ion concentration in the venturi loop was higher than that in the spray tower loop because of the water loss in humidifying the flue gas in the venturi loop. However, because the sulfite ion was converted into nonscrubbing sulfate ion by forced oxidation, the higher magnesium ion concentration in the venturi loop did not enhance SO_2 removal in the venturi loop. The secondary purpose of the magnesium oxide addition was to determine whether the presence of magnesium ion had an effect on oxidation efficiency.

Table 6-2 presents the major test conditions and important test results for the six limestone runs with magnesium oxide addition. More detailed information for these runs is given in Section 6 of Reference 5.

An additional observation in this series of runs was that overall limestone utilization increased from 82 to 92 percent as the air rate to the oxidation tank was increased from 0 to 210 scfm. Presumably, the higher air rate improved agitation of the slurry and CO_2 stripping and promoted the limestone dissolution.

Table 6-2

RESULTS OF FORCED-OXIDATION TESTS WITH TWO SCRUBBER LOOPS ON THE VENTURI/SPRAY TOWER SYSTEM USING LIMESTONE SLURRY WITH ADDED MAGNESIUM OXIDE

Major Test Conditions	820-1A	820-1B	820-1C	821-1A	822-1A	822-1B
Fly ash loading	High	High	High	High	High	High
Flue gas rate, acfm @ 300°F	35,000	35,000	35,000	35,000	35,000	35,000
Slurry rate to venturi, gpm	600	600	600	600	600	600
Slurry rate to spray tower, gpm	1600	1600	1600	0	1600	1600[4]
Venturi percent solids recirculated (controlled)	15	15	15	15	15	15
Residence times, min: Oxidation tank	11.3	11.3	11.3	11.3	11.3	11.3
Desupersaturation tank	4.7	4.7	4.7	4.7	4.7	4.7
Spray tower EHT	14.7	14.7	14.7	-	14.7	14.7
Venturi inlet (oxidation tank) pH (controlled)	5.5	-	-	5.5	-	-
Spray tower limestone stoichiometric ratio (based on solids)	-	1.6[5]	1.6[5]	-	1.6[5]	1.6[5]
Effective Mg^{++} concentration (S.T. loop), ppm	5000	5000	5000	5000	5000	5000
Venturi pressure drop, in. H_2O	9	9	9	9	9	9
Oxidation tank level, ft	18	18	18	18	18	18
Air rate to oxidation tank, scfm[1]	210	150	0	210	210	210
Clarified liquor returned to[2]	V.	V.	V.	V.	V.	V.
Selected Results						
Percent SO_2 removal	96	94	91	-	91	90
Inlet SO_2 concentration, ppm	2250	2500	2750	-	2750	2400
Spray tower percent solids recirculated	6.0	8.3	10.5	-[6]	8.0	5.6
Spray tower inlet pH	6.05	5.9	5.9	-	5.75	5.55
Spray tower limestone stoichiometric ratio (based on total slurry)	1.16	1.28	1.52	-	1.55	1.21
Spray tower inlet liquor gypsum saturation, %	100	105	90	-	100	110
Spray tower sulfite oxidation, %	30	17	20	-	21	23
Effective Mg^{++} concentration (S.T. loop), ppm	5150	4985	4700	-	4895	4845
Overall sulfite oxidation, %	98	92	36	-	97	98
Overall limestone utilization, %	92	90	82	-	79	93
Venturi inlet liquor gypsum saturation, %	130	130	145	-	125	130
Venturi inlet liquor sulfite concentration, ppm	50	950	5585	-	735	410
Air stoichiometry, atoms O/mole SO_2 absorbed	1.70	1.10	0	-	1.45	1.70
Filter cake solids, wt%[3]	85	82	63	-	85	85
Onstream hours	462	137	134	-	232	85

Notes:

(1) Air discharged downward through 3-inch diameter pipe with an open elbow at center of oxidation tank about 3 inches from tank bottom.
(2) Venturi loop (oxidation tank).
(3) Clarifier and filter used for solids dewatering in all runs.
(4) Spray tower turned off for 30 minutes every 8 hours to obtain SO_2 removal with venturi alone. Venturi SO_2 removal averaged 29%.
(5) In runs with control by spray tower stoichiometric ratio, the venturi inlet pH averaged 5.0.
(6) Run failed due to low MgO dissolution rate in spray tower effluent hold tank.

The following conclusions were drawn from the evaluation of the test results:

- The anticipated SO_2 removal enhancement was achieved. Under typical operating conditions, average overall SO_2 removal was 96 percent at 2250 ppm average inlet SO_2 concentration with 5150 ppm effective magnesium ion concentration in the spray tower (Run 820-1A). Under the same operating conditions but without magnesium oxide addition, overall SO_2 removal averaged 86 percent at 2550 ppm inlet SO_2 concentration (Run 818-1A, Table 6-1).
- Magnesium ion does not enhance SO_2 removal in a scrubber loop in which oxidation is forced, because sulfite ion is oxidized into nonscrubbing sulfate ion. SO_2 removal in the venturi loop (oxidation loop) was 29 percent (Run 822-1B with intermittent spray tower operation), which is typical of removal efficiency with limestone slurry in the absence of magnesium ion.
- The oxidation efficiency appeared to be unaffected, if not improved, by the presence of magnesium ion. Under typical conditions, sulfite oxidation was 98, 92, and 36 percent at 1.7, 1.1 and 0 air stoichiometry, respectively (Runs 820-1A, 820-1B, and 820-1C, respectively). Nearly complete oxidation appeared to be possible at an air stoichiometric ratio as low as 1.3.
- Filter cake solids concentration at 98 percent oxidation averaged 85 percent, demonstrating that magnesium oxide addition does not adversely affect the dewatering characteristics of oxidized sludge.

6.1.4 Tests with Lime

In this subsection, the results of forced-oxidation lime tests with a two-scrubber-loop configuration on the venturi/spray tower system are presented. A total of 20 lime runs were made. These included 10 runs each with high and low fly ash loadings in the flue gas. Tests with high fly ash loading included a one-month lime reliablility run. Except for the one-month reliability run, each test normally lasted 5 to 6 days, a time period which was judged sufficient to reach kinetic equilibrium and to allow collection of adequate run data.

Table 6-3 summarizes the major test conditions and important test results for the two-scrubber-loop forced-oxidation lime runs. Additional detailed information for these runs can be found in Section 7 of Reference 5.

The operating characteristics and test results of the two-scrubber-loop forced-oxidation lime tests were similar to those of limestone tests in many aspects (see Section 6.1.2). The following conclusions were made based on the results of lime testing from the venturi/spray tower system:

- Forced oxidation of sulfite to sulfate in the first of two independent scrubbing loops was successfully demonstrated in the two-scrubber-loop venturi/spray tower system with lime slurry. Successful demonstration of the forced oxidation was culminated with a one-month reliability lime test using flue gas with high fly ash loading.
- Under the one-month reliability test conditions of 18,000 to 35,000 acfm gas rate, 600 gpm venturi slurry rate, 1600 gpm spray tower slurry rate, 15 percent venturi slurry solids concentration, 18-ft oxidation tank level, and 5.5 oxidation tank pH, an average sulfite oxidation of 97 percent was achieved with air stoichiometric ratios ranging from 1.40 to 2.75 atoms oxygen/mole SO_2 absorbed. The filter cake solids concentration averaged 85 percent.
- As with limestone tests, ranges of conditions under which nearly complete sulfite oxidation (greater than 95 percent) was demonstrated were an oxidation tank pH of 4.5 to 5.5, oxidation tank level of at least 14 ft, and an air stoichiometry of at least 1.5 atoms oxygen/mole SO_2 absorbed. Filter cake solids contents of about 80 percent or higher were achieved under these conditions.
- The degree of sulfite oxidation was not affected when the venturi slurry solids concentration was dropped from the normal 15 percent to 8 percent by weight.
- Oxidation efficiency appeared to drop off at pH's greater than about 6.
- Sulfite oxidation of 90 percent or higher was required to obtain maximum improvement in waste solids dewatering characteristics.
- As with limestone tests, forced oxidation was achieved by simple air/slurry contact in the oxidation tank. Within the ranges of test conditions, air/slurry contact efficiency did not appear to be affected whether an air sparger with 130 1/8-inch holes, an air sparger with 40 1/4-inch holes, or a 3-inch diameter open pipe was used. Air/slurry contact was primarily achieved by the two-turbine agitator operated at 56 rpm and rated at 17 brake Hp.

Table 6-3

RESULTS OF TWO-SCRUBBER-LOOP FORCED-OXIDATION LIME TESTS ON THE VENTURI/SPRAY TOWER SYSTEM

Major Test Conditions	851-1A	852-1A	853-1A	854-1A	855-1A	856-1A	857-1A	858-1A
Fly ash loading	High	High	High	High	Low	Low	Low	Low
Gas rate, acfm @ 300°F	25,000	25,000	25,000	25,000	25,000	25,000	25,000	25,000
Venturi liquor rate, gpm	600	160	600	600	600	600	600	600
Spray tower liquor rate, gpm	1400	1400	1400	1400	1400	1400	1400	1400
Venturi percent solids recirculated (controlled)	15	15	15	15	15	15	15	8
Residence times, min: Oxidation tank	11.3	42	11.3	11.3	11.3	11.3	11.3	11.3
Desupersaturation tank	4.7	17.7	4.7	4.7	4.7	4.7	4.7	4.7
Spray tower EHT	18	18	18	18	18	18	18	18
Venturi inlet (oxidation tank) pH (controlled)	4.5	≥4.5(2)	≥4.5(3)	5.2	4.5(4)	5.0	5.5	5.5
Spray tower inlet pH (controlled)	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
Venturi pressure drop, in. H_2O	9	(min)	(min)	9	9	9	9	9
Oxidation tank level, ft	18	18	18	18	18	18	18	18
Air rate to oxidation tank, scfm	150(5)	150(5)	150(5)	150(5)	150(6)	150(6)	150(6)	150(6)
Clarified liquor returned to(8)	V. & S.T.	V. & S.T.	S.T.	S.T.	S.T.	S.T.	S.T.	V.
Selected Results								
Percent SO_2 removal	78	70	77	82	83	88	84	83
Inlet SO_2 concentration, ppm	3300	3400	3450	3150	2350	2500	2650	2750
Spray tower percent solids recirculated	6.0	8.3	6.4	6.1	7.3	7.9	7.9	15.2
Spray tower lime stoichiometric ratio	1.13	1.13	1.14	1.15	1.14	1.16	1.14	1.13
Spray tower inlet liquor gypsum saturation, %	80	50	80	55	95	90	90	85
Spray tower sulfite oxidation, %	15	13	14	11	18	12	11	14
Overall sulfite oxidation, %	97	83	97	96	98	97(9)	97	97
Overall lime utilization, %	98	96	95	97	98	98	99	98
Venturi inlet liquor gypsum saturation, %	95	105	100	100	105	95	100	110
Venturi inlet liquor sulfite concentration, ppm	39	22	35	35	24	36(9)	64	20
Air stoichiometry, atoms O/mole SO_2 absorbed	1.45	1.55	1.40	1.40	1.90	1.65	1.65	1.60
Filter cake solids, wt%(10)	81	73	78	79	75(11)	83(11)	78	81
Onstream hours	110	74	161	166	158	209	128	162

Note: Footnotes for this table are listed at the end of Table 6-3 (continued)

Table 6-3 (continued)

RESULTS OF TWO-SCRUBBER-LOOP FORCED-OXIDATION LIME TESTS ON THE VENTURI/SPRAY TOWER SYSTEM

	859-1A	859-1B	859-1C	859-1D	860-1A	861-1A
Major Test Condtions						
Fly ash loading	Low	Low	Low	Low	Low	Low
Gas rate, acfm @ 300°F	25,000	25,000	25,000	25,000	25,000	25,000
Venturi liquor rate, gpm	600	600	600	600	600	600
Spray tower liquor rate, gpm	1400	1400	1400	1400	1400	1400
Venturi percent solids recirculated (controlled)	15	15	15	15	15	15
Residence times, min: Oxidation tank	11.3	11.3	11.3	11.3	11.3	11.3
Desupersaturation tank	4.7	4.7	4.7	4.7	4.7	4.7
Spray tower EHT	18	18	18	18	12.6	18
Venturi inlet (oxidation tank) pH (controlled)	5.5	5.5	5.5	5.5	5.5	5.5
Spray tower inlet pH (controlled)	8.0	8.0	8.0	8.0	8.0	8.0
Venturi pressure drop, in. H_2O	9	9	9	9	9	9
Oxidation tank level, ft	18	13	18	18	18	18
Air rate to oxidation tank, scfm	135(6)	150(6)	100(6)	0	150(6)	150(7)
Clarified liquor returned to(8)	S.T.	S.T.	S.T.	S.T.	S.T.	S.T.
Selected Results						
Percent SO_2 removal	92	92	92	93	95	92
Inlet SO_2 concentration, ppm	2950	2700	2700	2600	2200	2700
Spray tower percent solids recirculated	7.2	7.6	7.3	7.1	7.0	7.3
Spray tower lime stoichiometric ratio	1.16	1.16	1.15	1.17	1.18	1.16
Spray tower inlet liquor gypsum saturation, %	60	90	90	50	70	90
Spray tower sulfite oxidation, %	10	12	20	10	10	19
Overall sulfite oxidation, %	76	99	69	30	99	98
Overall lime utilization, %	97	99	96	90	99	99
Venturi inlet liquor gypsum saturation, %	95	105	105	115	100	95
Venturi inlet liquor sulfite concentration, ppm	99	33	82	85	20	35
Air stoichiometry, atoms O/mole SO_2 absorbed	1.20	1.50	1.0	0	1.75	1.50
Filter cake solids, wt%(10)	74	78	71	55	82	86
Onstream hours	115	70	120	72	133	117

Table 6-3 (continued)

RESULTS OF TWO-SCRUBBER-LOOP FORCED-OXIDATION LIME TESTS ON THE VENTURI/SPRAY TOWER SYSTEM

Major Test Conditions	862-1A	863-1A	864-1A	865-1A	866-1A	867-1A
Fly ash lading	High	High	High	High	High	High
Gas rate, acfm @ 300°F	35,000	(1)	35,000	35,000	35,000	35,000
Venturi liquor rate, gpm	600	600	600	600	600	600
Spray tower liquor rate, gpm	1400	1600	1600	1600	1600	1600
Venturi percent solids recirculated (controlled)	15	15	15	15	15	15
Residence times, min: Oxidation tank	11.3	11.3	11.3	6.3	6.3	8.8
Desupersaturation tank	4.7	4.7	4.7	4.7	4.7	4.7
Spray tower EHT	18	14.7	14.7	14.7	14.7	14.7
Venturi inlet (oxidation tank) pH (controlled)	5.5	5.5	5.5	5.5	5.5	5.5
Spray tower inlet pH (controlled)	8.0	7.8	7.8	7.8	7.8	7.8
Venturi pressure drop, in. H_2O	9	9	9	9	9	9
Oxidation tank level, ft	18	18	18	10	10	14
Air rate to oxidation tank, scfm	210(7)	210(7)	210(7)	290/210(7)	350(7)	210(7)
Clarified liquor returned to(8)	V.	V. & S.T.	V. & S.T.	V. & S.T.	V. & S.T.	V. & S.T.
Selected Results						
Percent SO_2 removal	85	88	94	89	94	89
Inlet SO_2 concentration, ppm	2650	2950	2250	2300	1700/2400	2300
Spray tower percent solids recirculated	17.3	10.4	9.5	10.1	9.9	11.8
Spray tower lime stoichiometric ratio	1.11	1.11	1.13	1.10	1.15	1.12
Spray tower inlet liquor gypsum saturation, %	85	100	100	95	90	85
Spray tower sulfite oxidation, %	18	21	24	26	26	20
Overall sulfite oxidation, %	97	97	98	89	98/81	98
Overall lime utilization, %	98	98	99	98	98	99
Venturi inlet liquor gypsum saturation, %	105	105	100	100	95	90
Venturi inlet liquor sulfite concentration, ppm	30	35	25	65	40	40
Air stoichiometry, atoms O/mole SO_2 absorbed	1.65	1.40-2.75	1.75	2.10	3.85/2.70	1.80
Filter cake solids, wt%(10)	86	85	85	80	81	86
Onstream hours	162	779	115	254	159	137

Notes:

(1) Gas rate was varied from 18,000 to 35,000 acfm to follow the boiler load.
(2) Actual pH range was 4.6-6.2 (avg. 5.6).
(3) Actual pH range was 4.3-5.2 (avg. 4.8).
(4) Actual average pH was 4.7.
(5) Used a sparger ring located 6 inches from tank bottom. The sparger ring had 130 1/8-inch holes on the bottom side.
(6) Used a sparger ring located 6 inches from tank bottom. The sparger ring had 40 1/4-inch holes on the bottom side.
(7) Air discharged downward through a 3-inch diameter pipe with an open elbow at center of oxidation tank about 3 inches from tank bottom.
(8) Spray tower loop (effluent hold tank) or venturi loop (oxidation tank).
(9) Excluded a period 7/2/77-7/5/77 in which oxidation dropped to as low as 62% for unknown reason.
(10) Clarifier and filter in series used for solids dewatering in all runs.
(11) Intermittent filter operation.

- Slurries with high and low fly ash loadings oxidized equally well.

- Independent lime addition to both scrubber loops was necessary to have smooth ventui and spray tower inlet pH control.

- As in the limestone tests, the venturi inlet slurry liquor constantly exhibited a gypsum saturation level of about 100 percent when oxidation was forced within the venturi loop. This was probably the result of the abundance of gypsum crystal seeds produced by forced oxidation. The 100 percent saturation level is well below the incipient scaling level of 135 percent.

- Lime utilization in the spray tower averaged about 88 percent. Overall lime utilization averaged 98 percent, demonstrating the advantage of a two-scrubber loop system.

- Spray tower scaling (mostly by calcium sulfite) may occur when the recirculated slurry solids concentration in the spray tower drops below about 7 percent (low fly ash loading). This is especially true when the spray tower outlet pH stays above about 5.5.

- Oxidation efficiency did not appear to be affected when the oxidation tank level was dropped from 18 ft to 14 ft at 1.8 air stoichiometry and 5.5 pH. At a 10-ft tank level, an air stoichiometry approaching 4 was required to obtain nearly complete oxidation.

6.2 FORCED OXIDATION WITH ONE SCRUBBER LOOP ON THE TCA SYSTEM

Forced oxidation with good SO_2 removal in a single scrubber loop was demonstrated in the TCA system using limestone slurry. In this arrangement, sulfite oxidation was achieved by contacting the slurry with air in the scrubber hold tank. A compromise was made in the scrubber liquor pH between a higher pH desired for good SO_2 removal and a lower pH desired for good oxidation. Although the optimum oxidation rate occurs at about 4.5 pH, it was found that the oxidation rate was adequately fast up to a pH of about 6. Thus the oxidation pH range is compatible with the limestone scrubbing pH range of 5 to 6.

Forced oxidation in a single scrubber loop is detrimental to lime slurry scrubbing because sulfite ion, a major scrubbing species in a lime based scrubbing system, is removed in the oxidation process. Thus, forced oxidation substantially reduces SO_2 removal efficiency in a single loop lime system.

The single loop configuration was of prime interest commercially because the majority of commercial installations, both operating and planned, are of this type. Modification of these installations for forced oxidation would require as a minimum a compressor (or blower) plus an air sparger in the scrubber hold tank.

Two devices for air/slurry contact were tested on the TCA system. During the initial phase an air eductor was tested. Because of erosion problems and high energy consumption, the eductor was replaced with an air sparger similar to the one used in the venturi oxidation tank. All tests were conducted with flue gas containing high fly ash loadings.

6.2.1 Air Eductor System Description

An air eductor (Penberthy-Houdaille Model ELL-10 Special) was used to provide air/slurry contact. The high velocity of the slurry pumped through the eductor nozzle aspirated air into the liquid stream. The high shear developed in the throat of the eductor broke air into minute bubbles which were ejected into the oxidation tank, aerating the slurry in the tank.

The main feature of the eductor was its ability to create smaller air bubbles than could be obtained with an air sparger. This resulted in a higher mass transfer coefficient. However, the air eductor consumes more energy than an air sparger and is more prone to severe erosion in high-velocity slurry service.

The eductor used was capable of educting 600 scfm of air from the atmosphere at zero back pressure with a slurry flow rate of 1600 gpm. The eductor nozzle and a whirler within the nozzle were made of Stellite and the body was made of neoprene-lined carbon steel.

Two flow configurations were used on the one-scrubber-loop forced oxidation tests. In the one-tank configuration (Figure 6-3) slurry was recirculated from the TCA effluent hold tank (oxidation tank) through the eductor and back into the hold tank. The hold tank was 20 ft in diameter and operated at slurry levels from 6 to 12 feet. Limestone makeup was added either to the hold tank or to the pump suction of the scrubber recirculation line. In the two-tank configuration (Figure 6-4) a small downcomer tank (7-ft diameter) was used to receive the slurry from the scrubber. Slurry was then pumped from the downcomer tank through the eductor to the large hold tank (oxidation tank) where limestone was added. A slurry tie line connecting the two tanks equalized the slurry level in both tanks. The slurry flow through the eductor was maintained at a higher rate than the slurry flow to the scrubber. Thus there was always a slurry back-flow through the tie line from the hold tank to the downcomer tank. The two-tank configuration had the advantage that the pH of the slurry passing through the eductor was lower and thus the chemical reaction rate was higher.

In both one-tank and two-tank configurations, tests were made with the eductor mounted in both vertical and horizontal positions. In the vertical position as shown in Figures 6-3 and 6-4, the eductor was mounted above the effluent hold tank (oxidation tank) in an off-centered position and the air/slurry

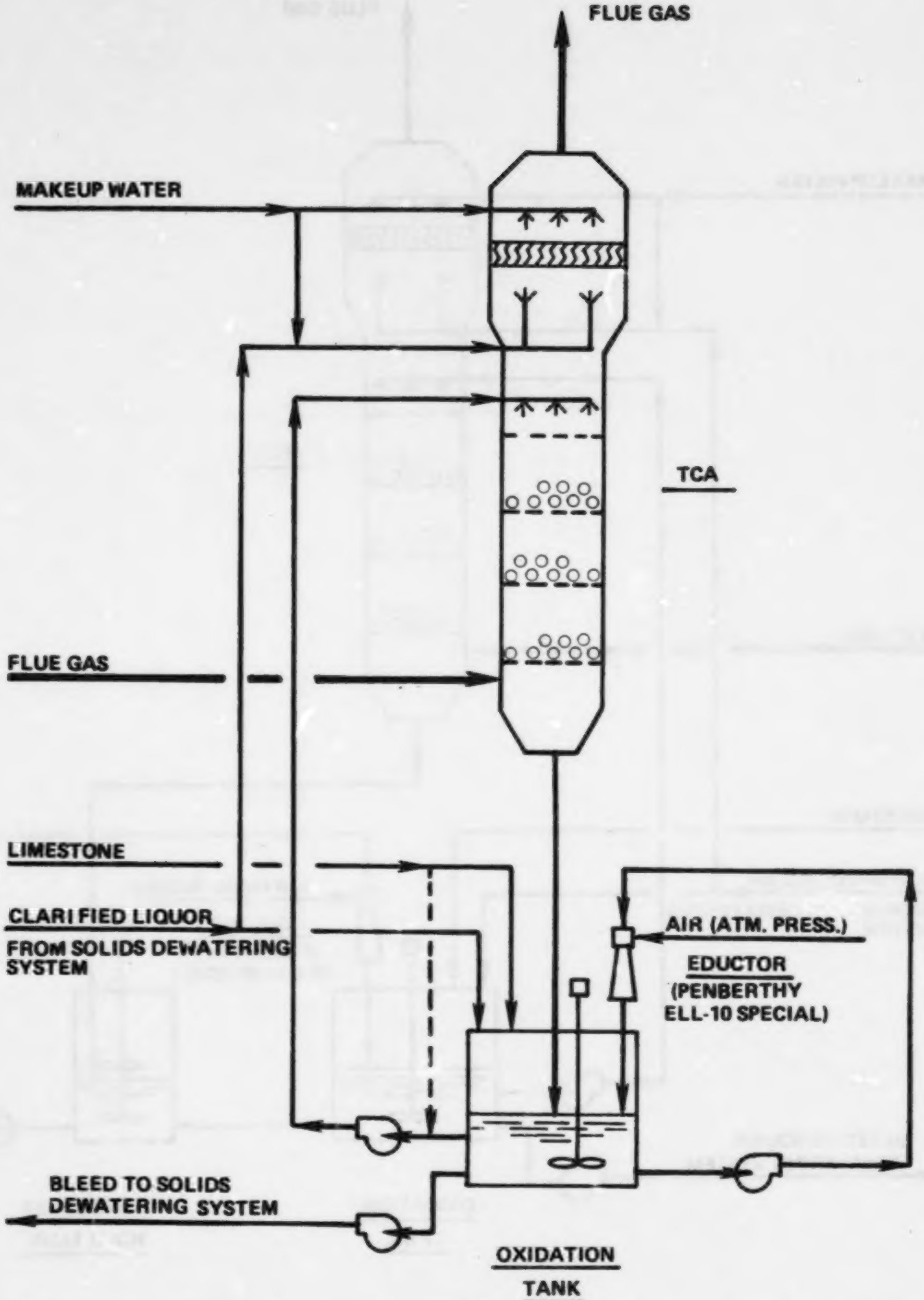

FLUE GAS
MAKEUP WATER
TCA
FLUE GAS
LIMESTONE
CLARIFIED LIQUOR
FROM SOLIDS DEWATERING SYSTEM
AIR (ATM. PRESS.)
EDUCTOR
(PENBERTHY ELL-10 SPECIAL)
BLEED TO SOLIDS DEWATERING SYSTEM
OXIDATION TANK

Figure 6-3. FLOW DIAGRAM FOR ONE-SCRUBBER-LOOP FORCED OXIDATION WITH AIR EDUCTOR IN THE TCA SYSTEM USING ONE TANK

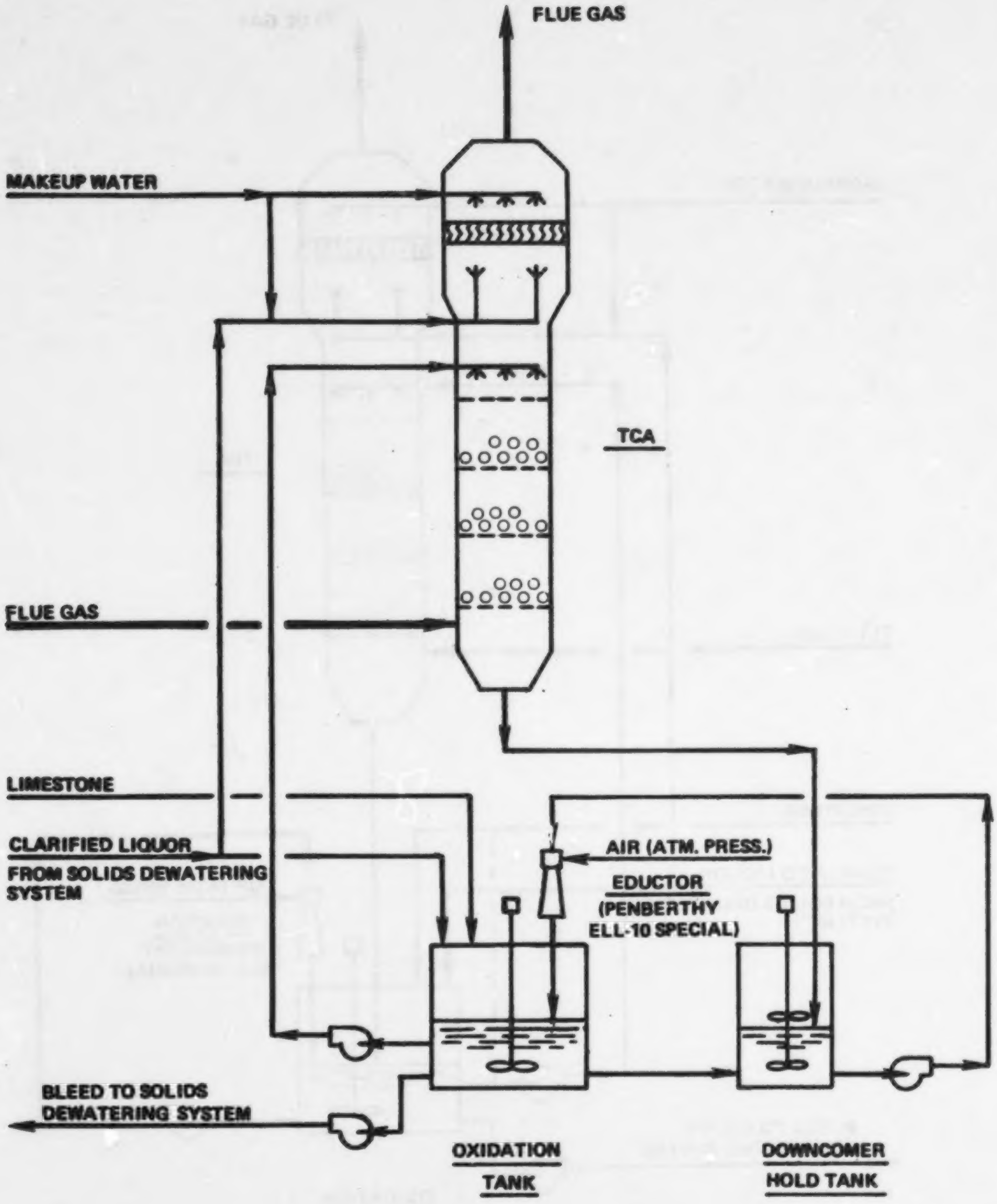

FLUE GAS
MAKEUP WATER
TCA
FLUE GAS
LIMESTONE
CLARIFIED LIQUOR
FROM SOLIDS DEWATERING SYSTEM
AIR (ATM. PRESS.)
EDUCTOR
(PENBERTHY
ELL-10 SPECIAL)
BLEED TO SOLIDS
DEWATERING SYSTEM
OXIDATION
TANK
DOWNCOMER
HOLD TANK

Figure 6-4. FLOW DIAGRAM FOR ONE-SCRUBBER-LOOP FORCED OXIDATION WITH AIR EDUCTOR IN THE TCA SYSTEM USING TWO TANKS

mixture was discharged vertically downward. Figure 6-5 shows the detailed arrangement of the oxidation tank with the eductor in vertical position. With the eductor in horizontal position (not shown in figures), air/slurry mixture was discharged into the oxidation tank through the tank wall in a horizontal, radial direction (at about 4 o'clock position on the plan view of Figure 6-5) and at an elevation 10 inches above the tank bottom.

6.2.2 Air Eductor Tests with Limestone

A total of 15 runs were made using limestone slurry with high fly ash loadings. These included 11 runs made with the air eductor mounted in a vertical position over the oxidation tank, and 4 runs with the eductor in a horizontal position beside the oxidation tank. Each test run normally lasted 5 to 6 days.

Table 6-4 summarizes the major test conditions and important test results for the 15 runs. Additional detailed information can be found in Section 12 of Reference 5.

The following conclusions were made from the results of these tests:

- Under the base case conditions of 30,000 acfm gas rate, 1200 gpm TCA slurry rate, 1600 gpm (with high fly ash loading), eductor slurry rate, 15 percent recirculated slurry solids (with fly ash), and 8 to 12 ft slurry level in the effluent hold tank (oxidation tank), sulfite oxidation of better than 90 percent was achieved at an eductor inlet pH range of 4.95 to 5.45 and air stoichiometric ratios as low as 2.0 atoms oxygen/mole SO_2 absorbed.
- The dewatering and handling characteristics of slurry solids oxidized to 90 percent or higher in a one-scrubber-loop system were as good as those in a two-scrubber-loop system.
- Operation in a two-tank configuration allowed for a higher pH to the TCA for good SO_2 removal and a lower pH to the eductor for good sulfite oxidation. Sulfite oxidations up to 98 percent were achieved with satisfactory SO_2 removal (80-89 percent).

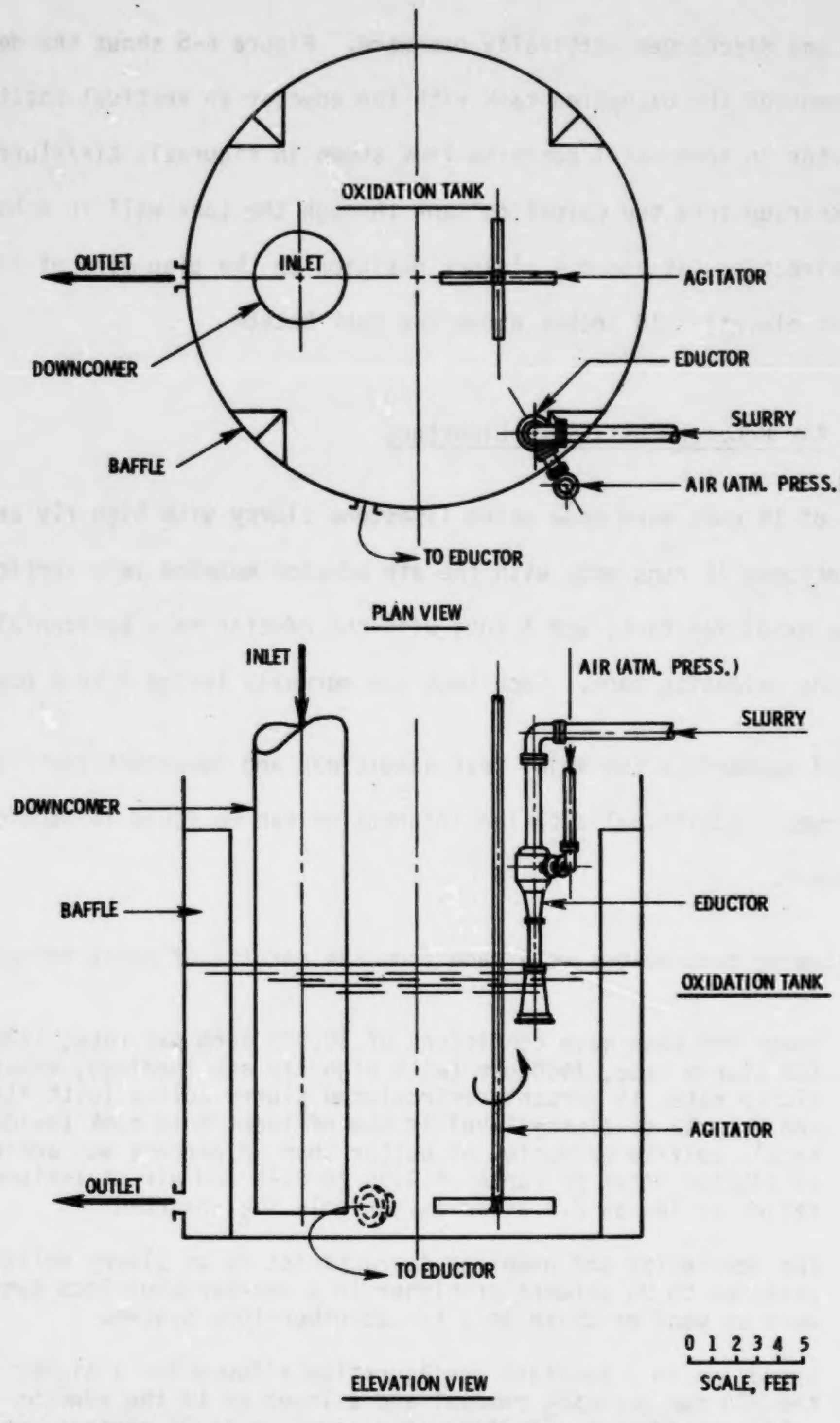

OXIDATION TANK
OUTLET
INLET
AGITATOR
DOWNCOMER
EDUCTOR
SLURRY
BAFFLE
AIR (ATM. PRESS.)
TO EDUCTOR
PLAN VIEW
INLET
AIR (ATM. PRESS.)
SLURRY
DOWNCOMER
EDUCTOR
BAFFLE
OXIDATION TANK
AGITATOR
OUTLET
TO EDUCTOR
0 1 2 3 4 5
SCALE, FEET
ELEVATION VIEW

Figure 6-5. ARRANGEMENT OF THE TCA OXIDATION TANK WITH EDUCTOR IN VERTICAL POSITION

Table 6-4

SUMMARY OF ONE-SCRUBBER-LOOP FORCED-OXIDATION LIMESTONE TESTS WITH AIR EDUCTOR ON THE TCA SYSTEM

Major Test Conditions	801-2A	801-2B	802-2A	803-2A	804-2A	805-2A	806-2A
Fly ash loading	High	High	High	High	High	High	High
Gas rate, acfm @ 300°F	30,000	30,000	30,000	30,000	30,000	30,000	30,000
Slurry flow rate to TCA, gpm	1200	1200	1200	1200	1200	1200	1200
Slurry flow rate to eductor, gpm	1600	1600	1600	1600	1600	1600	1200
Percent solids recirculated	15	15	15	15	15	15	15
EHT (oxidation tank) residence time, min.(1)	12	15.7	23.5	23.5	23.5	23.5	23.5
Downcomer (low pH) tank residence time, min.(1)	-	-	-	-	-	-	-
EHT level, ft	6.1	8.0	12	12	12	12	12
Eductor mounting position in EHT	Ver.	Ver.	Ver.	Ver.	Ver.	Ver.	Ver.
Eductor discharge point, ft from EHT bottom	6(4)	6(4)	10	10	10	10	10
Limestone stoichiometric ratio controlled at	1.2	1.2	1.2	-	-	-	-
TCA inlet pH controlled at	-	-	-	5.0	5.0	5.3	5.3
EHT (oxidation tank) agitator speed, rpm	45	45	45	45	68	68	68
Limestone addition point(2)	EHT	EHT	EHT	EHT	EHT	TCA	TCA
Air flow rate to eductor, scfm	~600	530	485	465	410	470	290
Selected Results							
Percent SO_2 removal	70	70	76	62	62	72	70
Inlet SO_2 concentration, ppm	2750	2750	2900	2950	3000	3050	3000
Percent sulfite oxidation	53	63	56	91	93	93	58
Air stoichiometry, atoms O/mole SO_2 absorbed	6.4	5.6	4.5	5.2	4.5	4.4	2.8
TCA inlet pH	5.8	5.8	5.75	5.05	5.0	5.35	5.35
Eductor inlet pH	5.8	5.8	5.75	5.05	5.0	5.25	5.3
Percent limestone utilization	80	80	82	90	93	84	91
Gypsum saturation in TCA inlet liquor, %	105	105	100	105	105	105	110
Onstream hours	102	47	142	165	166	140	115

Note: Footnotes for this table are listed in Table 6-4 (continued).

Table 6-4 (continued)

SUMMARY OF ONE-SCRUBBER-LOOP FORCED-OXIDATION LIMESTONE TESTS WITH AIR EDUCTOR ON THE TCA SYSTEM

Major Test Conditions	807-2A	808-2A	809-2A(3)	810-2A(3)	811-2A	812-2A	813-2A	814-2A
Fly ash loading	High	High	High	High	High	High	High	High
Gas rate, acfm @ 300°F	30,000	30,000	30,000	30,000	30,000	30,000	30,000	30,000
Slurry flow rate to TCA, gpm	1200	1200	1200	1200	1200	1200	1200	1200
Slurry flow rate to eductor, gpm	1600	1600	1600	1600	1600	1600	1600	1200
Percent solids recirculated	15	15	15	15	15	15	15	15
EHT (oxidation tank) residence time, min.(1)	23.5	23.5	15.7	15.7	23.5	15.7	23.5	15.7
Downcomer (low pH) tank residence time, min.(1)	2.9	2.9	1.9	1.9	2.9	1.9	-	-
EHT level, ft	12	12	8	8	12	8	12	8
Eductor mounting position in EHT	Ver.	Ver.	Ver.	Ver.	Hor.	Hor.	Hor.	Hor.
Eductor discharge point, ft from EHT bottom	10	10	6(4)	6(4)	0.8	0.8	0.8	0.8
Limestone stoichiometric ratio controlled at	-	1.3	1.3	-	1.3	1.3	-	-
TCA inlet pH controlled at	5.4	-	-	5.4	-	-	5.3	5.3
EHT (oxidation tank) agitator speed, rpm	68	68	68	68	68	68	68	68
Limestone addition point(2)	EHT	EHT	EHT	EHT	EHT	EHT	TCA	TCA
Air flow rate to eductor, scfm	475	200(5)	300(5)	300(5)	270	350	310	145
Selected Results								
Percent SO_2 removal	83	71	77	84	87	81	80	74
Inlet SO_2 concentration, ppm	2700	2900	3200	2900	2800	3000	2850	2550
Percent sulfite oxidation	96	93	96	98	96	93	95	61
Air stoichiometry, atoms O/mole SO_2 absorbed	4.3	2.0	2.5	2.5	2.3	2.9	2.8	1.6
TCA inlet pH	5.45	5.1	5.2	5.5	5.85	5.5	5.35	5.35
Eductor inlet pH	5.1	4.95	5.0	5.15	5.45	5.3	5.15	5.3
Percent limestone utilization	82	63	63	77	60	56	90	85
Gypsum saturation in TCA inlet liquor, %	100	125	115	110	100	100	90	115
Onstream hours	185	162	149	130	164	141	130	119

Notes:

(1) Residence times are based on slurry flow rate to TCA.
(2) EHT (effluent hold tank) or TCA (pump suction on the TCA inlet slurry line).
(3) Filter in series with clarifier was used during Runs 809-2A and 810-2A. Filter cake solids contents were 85 and 88%, respectively.
(4) At discharge of 4 ft long by 10-inch diameter pipe attached beneath the eductor.
(5) Air flow controlled by a sliding plate in the air intake line to eductor.

- With a single-tank configuration and limestone addition to the effluent hold tank, low hold tank pH (hence, low SO_2 removal) was necessary to achieve good sulfite oxidation. The SO_2 removal could be improved, however, by limestone addition to the TCA inlet slurry stream instead of the hold tank.

- SO_2 removal tended to be a few percentage points higher than the predicted SO_2 removal under similar operating conditions without forced oxidation. The reason for this removal enhancement is believed to be air stripping of CO_2 from the liquor, which increases the limestone dissolution rate.

- No significant difference in sulfite oxidation efficiency was observed between operations with the air eductor in the vertical, top-entry position or in the horizontal, bottom-entry position.

- Sulfite oxidation was unsatisfactory (about 60 percent) when the eductor slurry flow rate was reduced from 1600 to 1200 gpm. Decreased agitation in the oxidation tank at the lower flow rate is believed to be the main reason for poor oxidation, rather than the reduced air stoichiometric ratio.

- Air eduction by the eductor was as predicted by the manufacturer. Air flow rate was sensitive to the depth of the eductor's submergence in the slurry, ranging from 600 scfm at zero submergence to 200 scfm at 12 ft submergence, at a 1600 gpm slurry rate. 200 scfm of air was sufficient to achieve good sulfite oxidation at 1600 gpm slurry flow.

- Air/slurry contact was hampered by the configuration of the eductor discharge hold tank (20 ft diameter tank with only 8 to 12 ft normal liquid depth). A smaller diameter but deeper tank would probably have given better oxidation efficiency.

- Erosion of the air eductor (in limestone/fly ash service) was a problem. The eductor body was constructed of neoprene-lined carbon steel. The rubber near the nozzle had eroded in a circular pattern after 1500 operating hours, and the carbon steel body was eroded through after additional 550 hours. The Stellite nozzle and whirler showed only minor evidence of erosion.

6.2.3 Air Sparger System Description

Two operating configurations were used in the one-scrubber-loop forced-oxidation tests. With one tank as shown in Figure 6-6, effluent slurry from the TCA was discharged to the oxidation tank where limestone was added and the slurry was

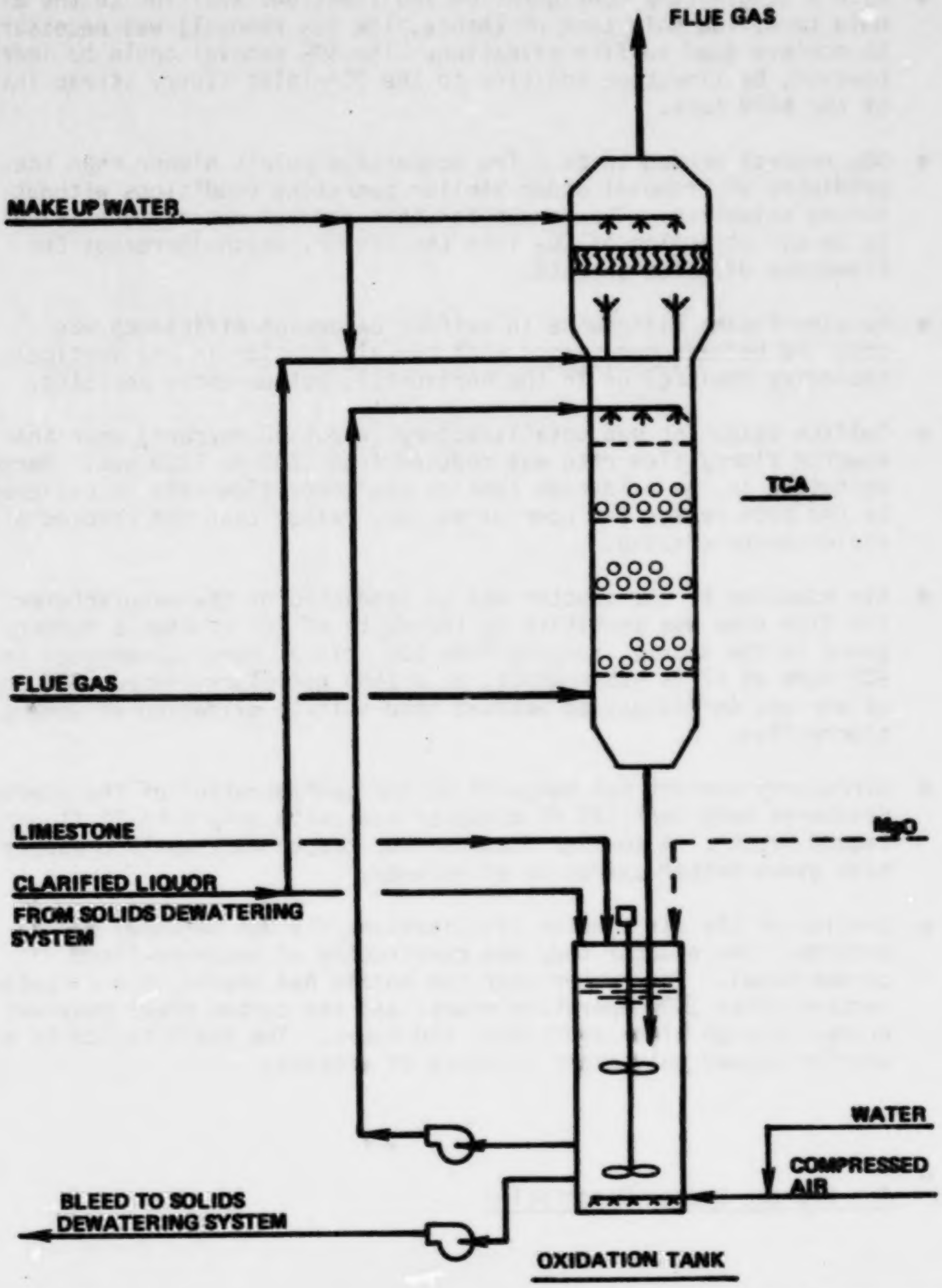

FLUE GAS
MAKE UP WATER
TCA
FLUE GAS
LIMESTONE
MgO
CLARIFIED LIQUOR
FROM SOLIDS DEWATERING
SYSTEM
WATER
COMPRESSED
AIR
BLEED TO SOLIDS
DEWATERING SYSTEM
OXIDATION TANK

Figure 6-6. FLOW DIAGRAM FOR ONE-SCRUBBER-LOOP FORCED OXIDATION WITH AIR SPARGER IN THE TCA SYSTEM USING ONE TANK

recycled back to the TCA. With two tanks in series as shown in Figure 6-7, effluent slurry was discharged to the oxidation tank and the slurry then overflowed to a second tank (effluent hold tank) where limestone was added. Slurry was recycled from the second tank back to the TCA.

Although the one-tank configuration is simpler, and modification of the existing full-scale installations to this forced oxidation scheme can be made readily (with the addition of an air sparger and a compressor or blower), a balance must be made in the single tank between the higher pH desired for good SO_2 removal and the lower pH desired for good sulfite oxidation. The two-tank configuration has the advantage of oxidizing the lower pH scrubber effluent slurry before limestone is added. The two-tank mode also provides better limestone utilization.

The oxidation tank arrangement is shown in Figure 6-8. The tank was 7 ft in diameter and was operated at a 17 to 18-ft level. All tests were conducted with an air sparger ring made of straight 3-inch 316L SS pipe pieces welded into an octagon of approximately 4-ft diameter. It was located 8 inches from the bottom of the tank and had 40 1/4-inch diameter holes pointed downward. The sparger ring was fed with compressed air to which sufficient water was added to assure humidification.

6.2.4 Air Sparger Tests with Limestone

The results of TCA one-scrubber-loop forced-oxidation limestone tests using an air eductor for air/slurry contact have been reported in Section 6.2.2. Erosion of the air eductor used in those tests was a major problem. Testing was terminated after about 2050 hours when the neoprene-lined carbon steel eductor body was eroded through.

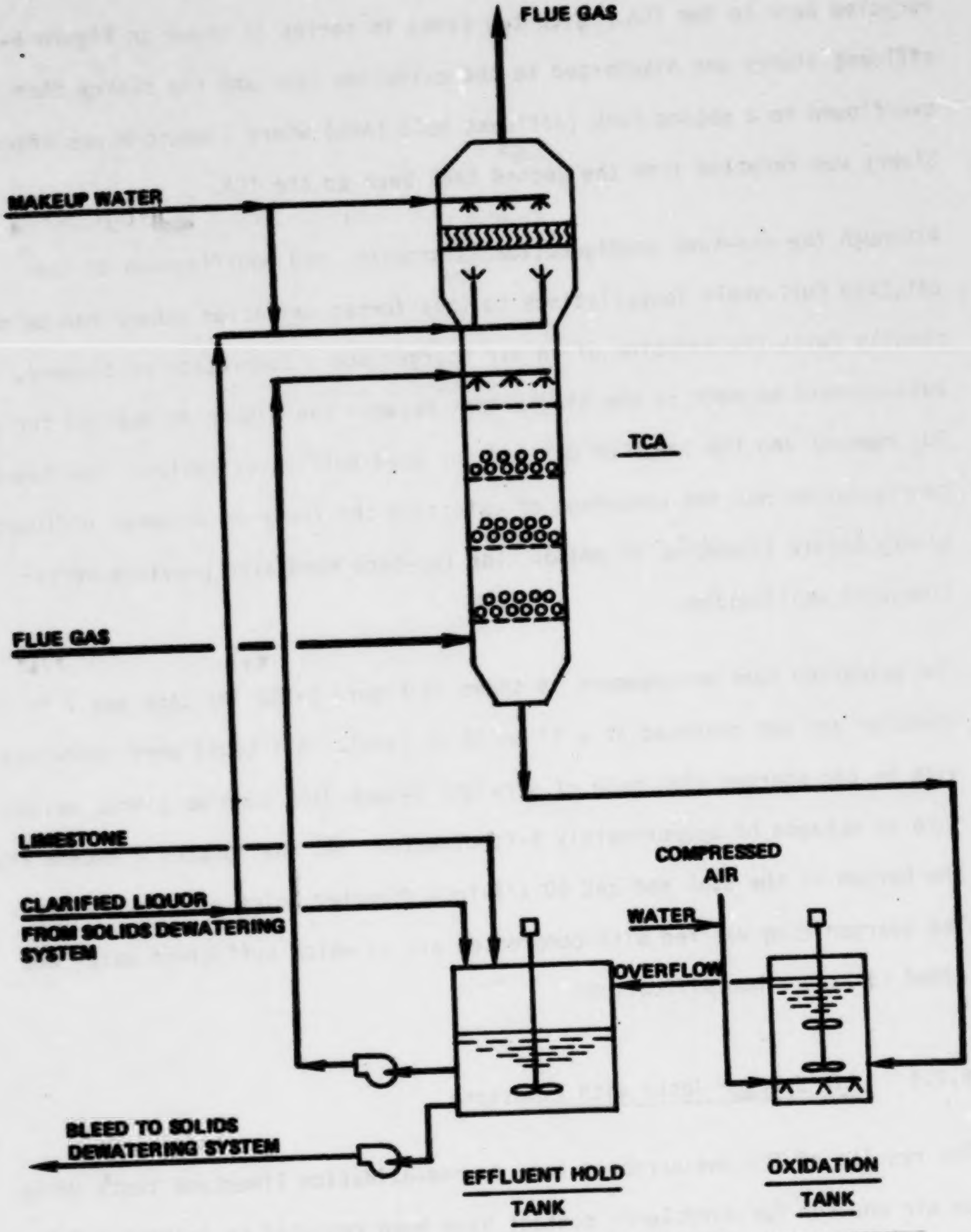

FLUE GAS
MAKEUP WATER
TCA
FLUE GAS
LIMESTONE
CLARIFIED LIQUOR FROM SOLIDS DEWATERING SYSTEM
COMPRESSED AIR
WATER
OVERFLOW
BLEED TO SOLIDS DEWATERING SYSTEM
EFFLUENT HOLD TANK
OXIDATION TANK

Figure 6-7. FLOW DIAGRAM FOR ONE-SCRUBBER-LOOP FORCED OXIDATION WITH AIR SPARGER IN THE TCA SYSTEM USING TWO TANKS

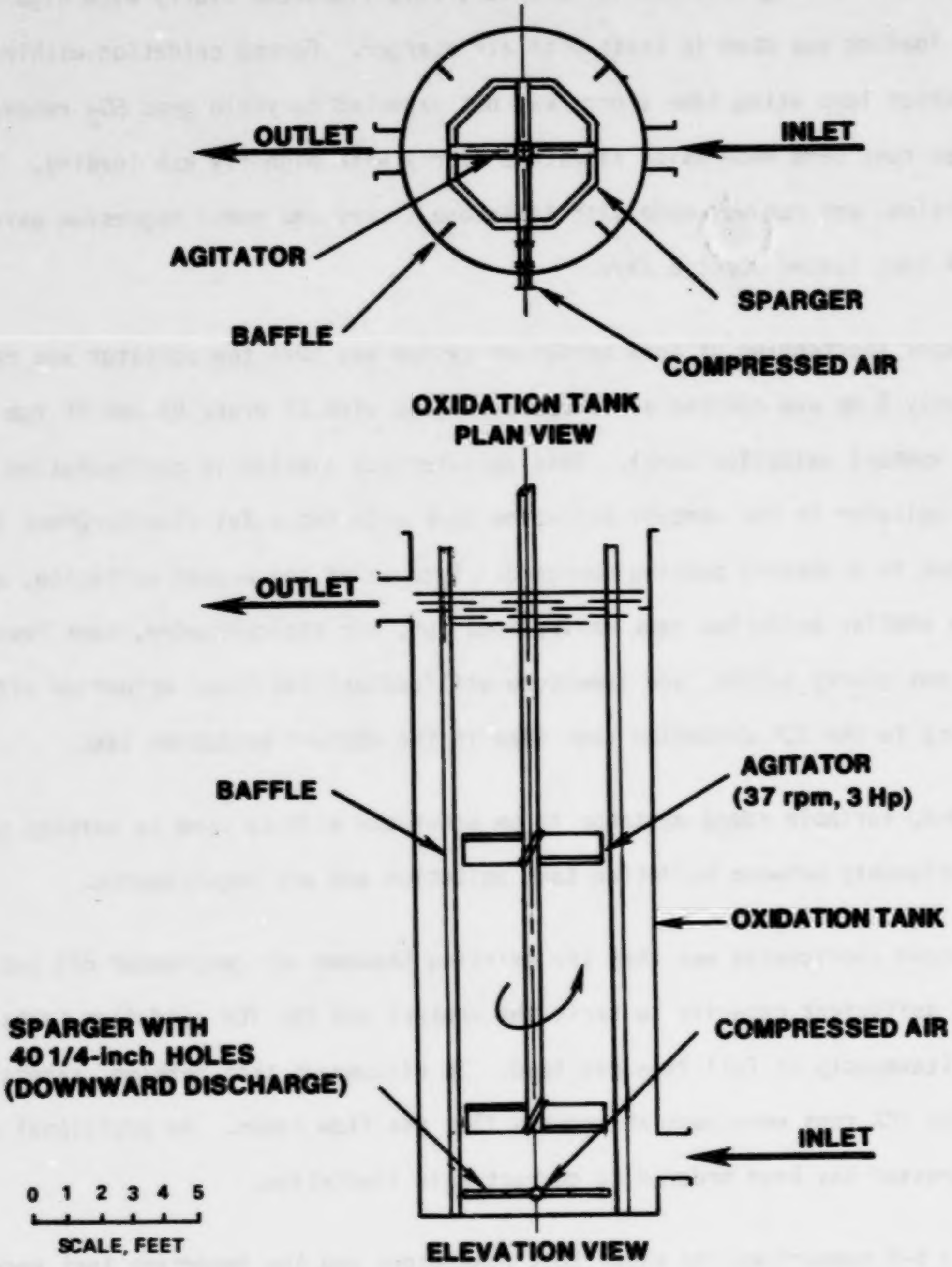

OUTLET
INLET
AGITATOR
SPARGER
BAFFLE
COMPRESSED AIR
OXIDATION TANK
PLAN VIEW
OUTLET
BAFFLE
AGITATOR
(37 rpm, 3 Hp)
OXIDATION TANK
SPARGER WITH
40 1/4-inch HOLES
(DOWNWARD DISCHARGE)
COMPRESSED AIR
INLET
0 1 2 3 4 5
SCALE, FEET
ELEVATION VIEW

Figure 6-8. Arrangement of the TCA Oxidation Tank with Air Sparger

As in the testing with the air eductor, only limestone slurry with high fly ash loading was used in tests with air sparger. Forced oxidation within the scrubber loop using lime slurry was not expected to yield good SO_2 removal. Seven runs were made using limestone slurry with high fly ash loading. In addition, one run was made with limestone slurry and added magnesium oxide. Each test lasted about 6 days.

A major shortcoming of this oxidation system was that the agitator was rated at only 3 Hp and rotated at 37 rpm (compared with 17 brake Hp and 56 rpm for the venturi oxidation tank). This agitator was similar in configuration to the agitator in the venturi oxidation tank with two axial flow turbines (49 inches in diameter) pumping downward. Because of the weaker agitation, runs with similar oxidation tank environment (pH, air stoichiometry, tank level, percent slurry solids, and limestone utilization) had lower oxidation efficiency in the TCA oxidation tank than in the venturi oxidation tank.

A 20-Hp variable speed agitator is on order and will be used to develop the relationship between oxidation tank agitation and air requirements.

A second shortcoming was that the existing Shawnee air compressor did not have sufficient capacity to serve the venturi and the TCA oxidation tanks simultaneously at full flue gas load. To circumvent this problem, several of the TCA runs were made at reduced flue gas flow rates. An additional air compressor has been ordered to correct this limitation.

Table 6-5 summarizes the major test conditions and the important test results. Detailed information concerning these runs can be found in Section 15 of Reference 5.

Table 6-5

SUMMARY OF ONE-SCRUBBER-LOOP FORCED-OXIDATION LIMESTONE TESTS WITH AIR SPARGER ON THE TCA SYSTEM

Major Test Conditions[2]	815-2A	816-2A	817-2A	818-2A	818-2B	819-2A	820-2A	821-2A
Fly ash loading	High	High	High	High	High	High	High	High
Flue gas rate, acfm @ 300°F	30,000	30,000	20,000	25,000	25,000	20,000	20,000	30,000
Slurry flow rate to TCA, gpm	1000	1000	1000	1000	1000	1000	1000	1200
Percent solids recirculated	15	15	15	15	15	15	15	15
Residence times, min: Oxidation tank	5.2	5.2	5.2	5.2	5.2	4.9	4.9	4.1
EHT	14.4	14.4	14.4	14.4	14.4	-	-	-
Oxidation tank level, ft	18	18	18	18	18	17	17	17
Air flow rate to oxidation tank	130	180	130	130	0	130	130	170
Limestone stoichiometric ratio (controlled)	1.3	1.3	1.3	1.3	1.3	1.3	-	1.2
TCA inlet pH (controlled)	-	-	-	-	-	-	5.9	-
Effective Mg^{++} concentration, ppm	-	-	-	-	-	-	-	5000
Limestone addition point	EHT	EHT	EHT	EHT	EHT	Oxid. Tk	Oxid. Tk	Oxid. Tk
Total static height of spheres, inches	20	22.5	22.5	22.5	22.5	22.5	22.5	15
Selected Results								
Percent SO_2 removal	89	91	79	85	82	75	79	84
Inlet SO_2 concentration, ppm	3000	2850	3000	3000	3300	2800	2500	2500
Percent sulfite oxidation	40	54	94	67	24	94	92	95
Air stoichiometry, atoms O/mole SO_2 absorbed	1.0	1.40	1.70	1.25	0	1.90	2.0	1.65
TCA inlet pH	6.25	6.25	5.8	6.2	6.2	5.55	5.65	5.35
Oxidation tank pH	-	5.7	5.45	5.65	-	5.55	5.65	5.35
Limestone utilization, %	80	76	81	77	81	77	62	79
Gypsum saturation in TCA inlet liquor, %	110	100	100	95	110	110	115	110
Effective Mg^{++} concentration, ppm	-	-	-	-	-	-	-	4960
Onstream hours	75	48	161	131	140	164	259	182

Notes:

(1) Used a sparger ring located 8 inches from the bottom of oxidation tank. The sparger ring had 40 1/4-inch diameter holes on the bottom side.

(2) Clarifier only was used for solids dewatering except for Run 821-2A in which clarifier and centrifuge were used. Centrifuge cake solids concentration was 79 percent.

Despite oxidation tank agitator and air compressor limitations, forced oxidation with an air sparger in a one-scrubber-loop TCA system was demonstrated. The following conclusions were made from the test results:

- With two tanks in series, 94 percent sulfite oxidation was achieved at an air stoichiometry of 1.7, oxidation tank pH of 5.45, and an oxidation tank level of 18 ft. Under similar oxidation tank environment, higher oxidation efficiency (95-99 percent) was achieved in the venturi oxidation tank. The poorer performance in the TCA system was attributed to the weaker agitation in the TCA oxidation tank.
- Higher air stoichiometry (about 1.9) was required to achieve a similar degree of oxidation (94 percent) in a one-tank configuration because of higher pH.
- Operation in the two-tank mode gave better limestone utilization and SO_2 removal than the one-tank mode.
- As expected, magnesium oxide addition did not enhance the SO_2 removal when oxidation was forced within the scrubber loop.

6.3 VENTURI/SPRAY TOWER BLEED STREAM OXIDATION

Bleed stream forced oxidation with limestone slurry and added magnesium oxide was successfully demonstrated in a month-long series of tests on the venturi/spray tower system. Oxidized slurry from these tests had good dewatering properties with filter cake solids concentration averaging about 84 percent. Thus, it is quite practical to improve the quality and reduce the volume of waste solids in installations incorporating magnesium ion in the slurry liquor by simple air/slurry contact of the bleed stream.

6.3.1 System Description

The venturi/spray tower system was arranged as shown in Figure 6-9 for the bleed stream oxidation tests. Both the venturi and the spray tower slurries

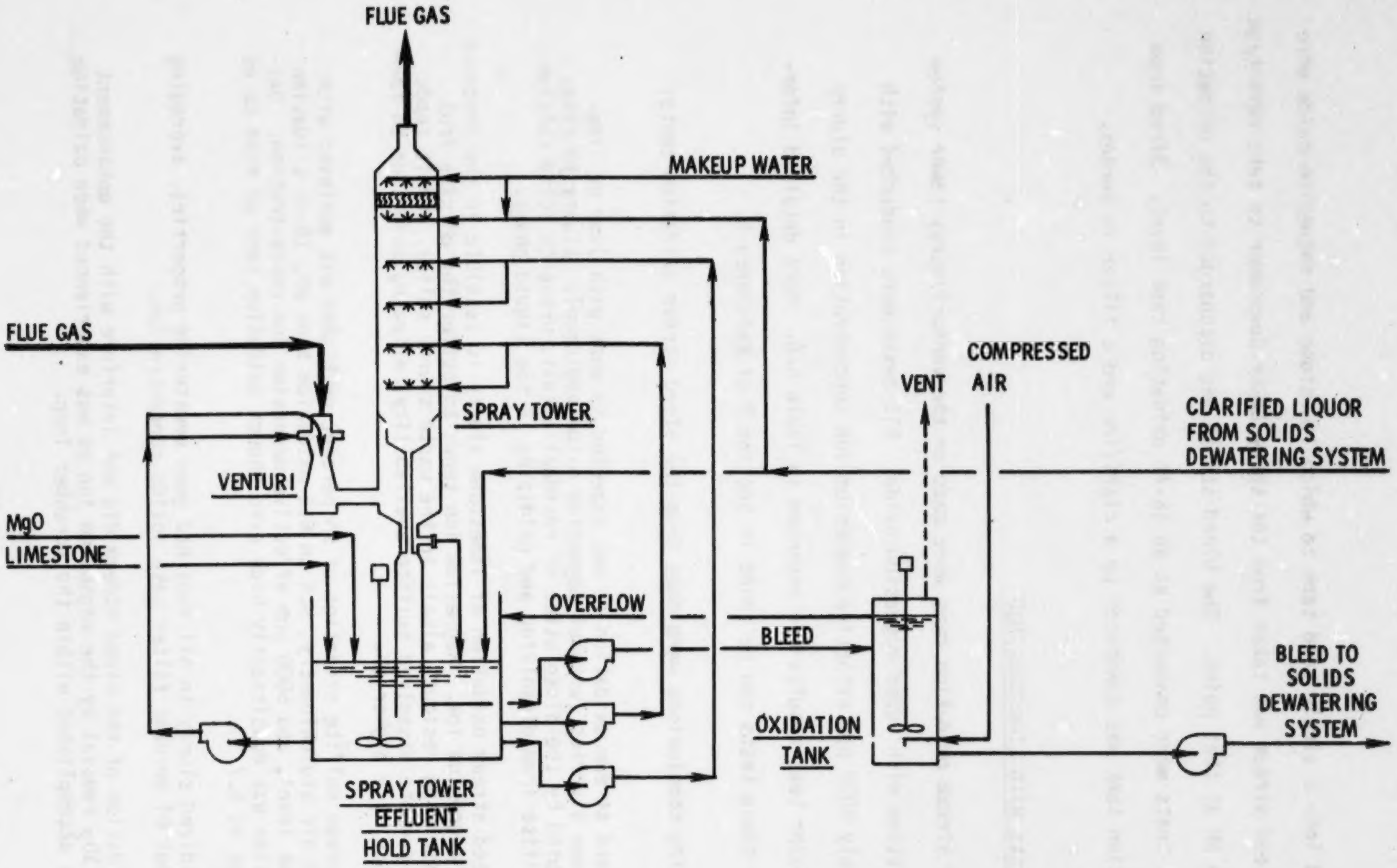

FLUE GAS
MAKEUP WATER
FLUE GAS
SPRAY TOWER
VENTURI
MgO
LIMESTONE
COMPRESSED AIR
VENT
CLARIFIED LIQUOR FROM SOLIDS DEWATERING SYSTEM
OVERFLOW
BLEED
OXIDATION TANK
BLEED TO SOLIDS DEWATERING SYSTEM
SPRAY TOWER EFFLUENT HOLD TANK

Figure 6-9. FLOW DIAGRAM FOR BLEED STREAM OXIDATION IN THE VENTURI/SPRAY TOWER SYSTEM

discharged into a single hold tank to which limestone and magnesium oxide were fed. A bleed stream was taken from the spray tower downcomer to take advantage of the low pH at that point. The bleed stream was discharged to the oxidation tank. All tests were conducted at an 18-ft oxidation tank level. Bleed from the oxidation tank was dewatered by a clarifier and a filter in series.

6.3.2 Tests with Limestone/MgO

Four bleed stream oxidation runs were made on the venturi/spray tower system using limestone with added magnesium oxide. All tests were conducted with approximately 5000 ppm effective magnesium ion concentration in the slurry liquor. Major test results are reported in Table 6-6. More detailed information for these tests can be found in Section 8 of Reference 5.

The following conclusions were made from the bleed stream oxidation tests:

- Bleed stream oxidation is not expected to work with lime or limestone slurries (without magnesium oxide addition). Slurry pH rise, caused by the dissolution of residual alkali, prevents solid calcium sulfite from dissolving and oxidizing in the liquid phase.
- Bleed stream oxidation of limestone slurry is feasible in the presence of magnesium ion. Magnesium ion tends to buffer the pH rise from dissolving residual alkali in the waste slurry solids, and it tends to promote dissolved sulfite availability, allowing oxidation to take place at a higher pH.
- Average sulfite oxidation of 96 percent or higher was achieved with 1.6 air stoichiometry, 5.4 to 6.3 oxidation tank pH, 18-ft oxidation tank level, and 5000 ppm effective magnesium ion concentration. Oxidation was consistently high even though oxidation tank pH rose to as high as 6.7.
- Oxidized slurry in all runs had good dewatering properties, averaging about 84 percent filter cake solids concentration.
- Oxidation of the bleed stream did not interfere with the enhancement of SO_2 removal by the magnesium ion as was experienced when oxidation was accomplished within the scrubber loop.

Table 6-6

RESULTS OF FORCED-OXIDATION TESTS ON THE VENTURI/SPRAY TOWER BLEED STREAM USING LIMESTONE SLURRY WITH ADDED MAGNESIUM OXIDE

Major Test Conditions	823-1A	824-1A	825-1A	826-1A
Fly ash loading	High	High	High	High
Flue gas rate, acfm @ 300°F	18,000	35,000	18,000	26,500(3)
Slurry rate to venturi, gpm	600	600	600	600
Slurry rate to spray tower, gpm	1600	1600	1600	1600
Percent solids recirculated (controlled)	15	15	15	15
EHT residence time, min	11.2	11.2	11.2	11.2
Spray tower inlet pH (controlled)	5.3	-	-	-
Scrubber limestone stoichiometric ratio (controlled)(based on solids)	-	1.9	1.4	1.4
Effective Mg^{++} concentration, ppm	5000	5000	5000	5000
Venturi pressure drop, in. H_2O	9	9	9	9
Oxidation tank level, ft	18	18	18	18
Air rate to oxidation tank, scfm(1)	110	210	110	210
Recycle flow from oxidation tank to EHT, gpm	30	30	0	0
Selected Results				
Percent SO_2 removal	94	88	95	89
Inlet SO_2 concentration, ppm	2600	2600	2500	2750
Scrubber percent solids recirculated	13.3	14.1	14.7	15.2
Scrubber inlet liquor pH	5.25	5.25	5.45	5.35
Oxidation pH	6.30	5.90	5.65	5.45
Limestone utilization, % (based on total slurry)	36	38	64	61
Sulfite oxidation in oxidation tank, %	98	97	97	96
Sulfite oxidation in scrubber inlet slurry, %	86	49	39	29
Gypsum saturation in scrubber inlet liquor, %	120	85	105	105
Gypsum saturation in oxidation tank, %	115	90	115	115
Effective Mg^{++} concentration in scrubber inlet liquor, ppm	4990	5215	5380	4970
Oxidation tank liquor sulfite concentration, ppm	65	105	220	230
Air stoichiometry, atoms O/mole SO_2 absorbed	1.55	1.60	1.60	2.0
Filter cake solids, wt%(2)	83	85	85	84
Onstream hours	205	159	229	246

Notes:

(1) Air discharged downward through 3-inch diameter pipe with an open elbow at center of oxidation tank about 3 inches from tank bottom.
(2) Clarifier and filter in series used for solids dewatering in all runs.
(3) Desired flow rate was 35,000 acfm but problems with the venturi plug lifting mechanism limited the rate to 26,500 acfm.

- In two runs (Run 823-1A and 824-1A), 30 gpm of oxidized slurry was recycled from the oxidation tank back to the scrubber effluent hold tank in an attempt to reduce the pH difference between the two tanks. However, the opposite occurred. The hold tank pH was depressed, requiring excess limestone feed to maintain a pH of 5.3, resulting in a very poor limestone utilization (less than 40 percent). This phenomenon was attributed to the limestone blinding by $CaSO_3$ precipitated in the scrubber slurry loop. Sufficient $CaSO_3$ crystal seeds were not available because the slurry had high gypsum content caused by the recycle stream. The 30 gpm recycle flow proved to be unecessary in the succeeding two runs (Run 825-1A and 826-1A). Without the recycle flow, the pH difference betweeen the two tanks averaged only 0.1 and 0.2 pH units with the oxidation tank pH averaging 5.65 or less.

Section 7

MATHEMATICAL MODEL FOR SO_2 REMOVAL WITH CORRELATIONS OF SHAWNEE DATA

Correlations of data are presented here for sulfur dioxide (SO_2) removal achieved by the Shawnee spray tower and TCA scrubbers between October 1973 and November 1977. The data are for limestone and lime alkali with and without magnesia (MgO) additive, and without forced oxidation.

The Shawnee spray tower has four spray banks on a 4-ft spacing, each with seven nozzles with about 12 psi of pressure drop. The TCA contains three beds of mobile packing spheres and four retaining grids. The sphere diameter was 1.5 inches during the period in which the correlated data were obtained.

Fractional SO_2 removal was measured both for short-term factorial tests (February through April, 1976) with about 8 hours of steady-state operation, and for long-term tests lasting four days or more (usually about one to four weeks), often at widely fluctuating inlet SO_2 concentrations (1500 to 4500 ppm) and SO_2 removals. For most of the spray tower long-term tests the venturi scrubber was operated at 9 in. H_2O pressure drop and 600 gpm slurry flow rate in series with and upstream of the spray tower. The factorial tests were specifically designed for statistical analysis of SO_2 removal data; the long-term tests were primarily designed to demonstrate reliability of system operation. Run-averaged data for the long-term tests sufficiently agree with the factorial data to justify overall correlation of both.

The correlations of Shawnee data for SO_2 removal follow the form of a semi-theoretical mathematical model that is compatible with boundary constraints on SO_2 removal and the operating variables (e.g., SO_2 removal between zero and 100 percent, and zero removal at zero liquor rate). The correlations permit reasonable extrapolations beyond the range of the fitted data. For the TCA, the possibility of flooding (excessive pressure drop) should be considered when extrapolating beyond the ranges of gas and slurry flow rates investigated.

The variables strongly affecting SO_2 removal in the correlated tests were slurry flow rate in the TCA (Section 9.1.3), liquid-to-gas ratio in the spray tower, inlet liquor pH for both scrubbers, effective magnesium ion concentration for both scrubbers, and total height of mobile packing spheres in the TCA. Limitations in the range of data did not permit a thorough understanding of the effects of inlet gas SO_2 concentration and scrubber slurry nozzle pressure drop on fraction SO_2 removal. The available data indicated that fraction SO_2 removal decreases strongly with increasing inlet SO_2 concentration. In some cases minor effects of gas velocity and chloride ion concentration (Section 3.2.6) were present.

Shawnee correlations for SO_2 removal have been inserted into the Joint TVA/Bechtel Economics Study Computer Program (Reference 16). The correlations are used by TVA, Bechtel National Inc.'s Air Quality Group, and others for preliminary design of new SO_2 wet scrubbing installations and for preliminary estimation of SO_2 removal for planned tests at Shawnee.

7.1 DEVELOPMENT OF THE MODEL

For absorption of SO_2 from the gas phase into the liquid phase, the following differential equation applies (Reference 17):

$$-v\ d(SO_2) = K_G a\ [SO_2 - (SO_2)_e]\ dz = \frac{[SO_2 - (SO_2)_e]\ dz}{\frac{1}{k_G a} + \frac{H}{k_L^{\circ} a \bar{\phi}}} \qquad (7\text{-}1)$$

where:

K_G = overall gas mass transfer coefficient, based on both liquid-side and gas-side resistances to mass transfer, ft/sec

k_G = gas-side mass transfer coefficient, ft/sec

k_L° = liquid-side mass transfer coefficient for physical absorption, ft/sec

a = gas-liquid interfacial area per scrubber volume, ft^2/ft^3

$\bar{\phi}$ = average chemical reaction enhancement factor for mass transfer in the liquid film, dimensionless

v = scrubber gas velocity, ft/sec

z = vertical distance in the scrubber, ft

SO_2 = mole fraction of SO_2 in the gas phase at a given value of z

$(SO_2)_e$ = mole fraction of SO_2 in the gas phase that would be in equilibrium with the liquid phase

H = Henry's Law constant for SO_2, mole fraction in gas/mole fraction in liquor

Analysis of typical Shawnee limestone/lime wet scrubbing liquors, by use of an equilibrium computer program developed by Radian Corporation and modified by Bechtel (References 1 and 18), has shown that the equilibrium SO_2 is much less than the actual SO_2. Also, a comparison of Shawnee limestone/lime scrubbing data with earlier Shawnee data (June-August 1972) for gas-side controlled soda-ash scrubbing has shown that liquid-side resistance is dominant, i.e., $k_L^\circ/H \ll k_G$, for limestone/lime scrubbing (Reference 19). Under these conditions of negligible $(SO_2)_e$ and $(1/k_Ga)$, Equation 7-1 can be simplified to:

$$-v\, d(SO_2) = (k_L^\circ a\bar{\phi}/H)\, SO_2\, dz \qquad (7\text{-}2)$$

Integration of Equation 7-2 across the entire vertical height of the scrubber and under the assumption that the ratio $(k_L^\circ a/H)$ is constant yields:

$$\begin{matrix}\text{Fraction} \\ \text{Removal}\end{matrix}\ SO_2 = 1 - \exp\left[-\bar{\phi} k_L^\circ az/Hv\right] \qquad (7\text{-}3)$$

7.1.1 Physical Absorption

Equation 7-4 below represents the physical absorption group, $k_L^\circ a\, z/Hv$, in a form that fits boundary constraints on SO_2 removal, slurry flow rate, gas flow rate, and total height of spheres (TCA only).

$$k_L^\circ az/Hv = \alpha_1\, L^{\alpha 2}\, (1/v)^{\alpha 3} \exp\,(\alpha_4\, h_{tot}) \qquad (7\text{-}4)$$

where:

L = slurry flow rate per cross-sectional area, gpm/ft^2

h_{tot} = total height of spheres in the TCA, inches (zero for the spray tower)

α's = positive constant coefficients to be fitted to limestone/lime wet-scrubbing data

Equation 7-4 conforms to the expectation that $(k_L^\circ a)$ increases with slurry flow rate (Reference 17) and that $(k_L^\circ az)$ in the TCA increases with height of spheres.

7.1.2 Chemical Reaction

The parameter Φ in Equation 7-3 represents the chemical reactivity of the scrubber liquor with absorbed SO_2 gas. This chemical reactivity should increase with increasing scrubber liquor pH, increasing effective magnesium ion concentration, and decreasing inlet gas SO_2 concentration. An empirical relationship for Φ, expressed in terms of these chemical operating variables and compatible with boundary constraints on SO_2 removal, is:

$$\Phi = \exp\left[\alpha_5\, pH_i + \alpha_6\, (Mg)_e - \alpha_7\, (SO_2)_i\right] \tag{7-5}$$

where:

pH_i = scrubber inlet liquor pH

$(Mg)_e$ = effective magnesium ion concentration, ppm

= [ppm Mg^{++} - (ppm Cl^-/2.92)] for $Mg^{++} > Cl^-/2.92$

= 0 for $Mg^{++} \leq Cl^-/2.92$

where 2.92 = ratio by weight of Cl^- to Mg^{++} in $MgCl_2$

$(SO_2)_i$ = scrubber inlet gas SO_2 concentration, ppm

α's = positive constant coefficients fitted to the data

The increase in chemical reactivity with an increase in pH is due to the additional alkali stoichiometry needed to maintain the higher pH.

Chemical reactivity can also be increased by addition of magnesia (MgO). Dissolution of MgO into the liquor provides Mg^{++} ion, thus increasing the total cation concentration. To maintain electroneutrality additional anions must be dissolved. Therefore, the concentrations of sulfite and sulfate as ionic sulfite, bisulfite, and sulfate ($SO_3^=$, HSO_3^-, and $SO_4^=$) increase with increasing magnesium. The sulfite ion, $SO_3^=$, and its ion pair with magnesium, $MgSO_3^\circ$ (which also increases as both Mg^{++} and $SO_3^=$ increase), can react with incoming SO_2 gas to form bisulfite ion, HSO_3^-.

$$SO_2\ (aq) + SO_3^= + H_2O \rightleftarrows 2\ HSO_3^- \qquad (7\text{-}6a)$$

$$SO_2\ (aq) + MgSO_3^\circ + H_2O \rightleftarrows 2\ HSO_3^- + Mg^{++} \qquad (7\text{-}6b)$$

This removal of aqueous SO_2 by chemical reaction increases the ability of the liquor to absorb more SO_2.

Any chloride present in the liquor reacts with magnesium to form $MgCl_2$, which does not react with SO_2. Magnesium stoichiometrically equivalent to measured chloride is subtracted from the total dissolved magnesium to obtain the effective magnesium ion concentration.

Equation 7-5 predicts that SO_2 removal efficiency decreases with increasing $(SO_2)_i$. For the mass transfer conditions in limestone/lime scrubbing, i.e., negligible $(SO_2)_e$ and negligible gas phase resistance, SO_2 (aq) at the gas-liquid interface increases in direct proportion to the SO_2 gas concentration. This increase in SO_2 (aq) lowers the pH at the interface, reducing liquor reactivity and the fraction of acidic SO_2 gas absorbed. This decrease in SO_2 removal with increasing SO_2 gas concentration has also been observed at other limestone/lime wet scrubbing installations (References 20, 21, and 22).

7.1.3 Final Form of the Model

The semi-theoretical form of the model for fraction SO_2 removal is obtained by combining Equations 7-3 through 7-5:

$$\text{Fraction SO}_2\text{ Removal} = 1 - \exp\left\{ -\alpha_1 L^{\alpha_2} (1/v)^{\alpha_3} \exp\left[\alpha_4 h_{tot} + \alpha_5 pH_i + \alpha_6 (Mg)_e - \alpha_7 (SO_2)_i\right]\right\} \quad (7\text{-}7)$$

For the spray tower with lime an additional term, α_8 Cl (Cl = Dissolved chloride ion concentration, ppm) was required in Equations 7-5 and 7-7 to adequately correlate the data. This is discussed further below.

7.2 CORRELATIONS OF SHAWNEE DATA FOR SO_2 REMOVAL

Equation 7-7 has been correlated to Shawnee spray tower and TCA limestone/lime wet scrubbing data. The resulting correlations are summarized in Table 7-1. The correlations explain about 88 percent of the variation in the data, i.e., the square of the correlation coefficient is 0.88. The standard errors of estimate are about four percent SO_2 removal.

The operating variables having the greatest statistical significance in fitting the data were slurry flow rate in the TCA, liquid-to-gas ratio (proportional to L/v) in the spray tower, scrubber inlet liquor pH, effective magnesium, and total height of spheres in the TCA.

The correlated data cover the following ranges of the operating variables:

L = 14-32 gpm/ft^2 for the spray tower and 18-38 gpm/ft^2 for the TCA

v = 5.3-9.3 ft/sec for the spray tower and 8.3-12.5 ft/sec for the TCA

h_{tot} = 0-22.5 inches

pH_i = 5.1-5.9 for limestone and 6.0-9.0 for lime

$(Mg)_e$ = 0-10,000 ppm for limestone, 0-2500 ppm for the spray tower with lime, and 0-4000 ppm for the TCA with lime

$(SO_2)_i$ = 1500-4500 ppm for the TCA with limestone, and 2300-3500 ppm otherwise

Cl = 1000-20,000 ppm

For the TCA scrubber with limestone alkali Figure 7-1 shows measured percent SO_2 removals and those predicted by Equation 7-7 with the coefficients indicated in Table 7-1. Figure 7-1 shows that the fit is good for both the 100 factorial tests and the 82 long-term tests.

The effect of $(SO_2)_i$ for the TCA with limestone was determined as $\alpha_7 = 1.5 \times 10^{-4}$. This is in good agreement with a separate analysis of 213 individual data points from Shawnee TCA limestone long-term Runs 535-2A and 535-2B and with an analysis of four limestone data points at varying $(SO_2)_i$ from a 300-acfm TCA at the EPA-IERL pilot plant (Reference 4 and 20). The two Shawnee runs operated for 2325 hours from September through December, 1974, with an inlet SO_2 range of 1500 to 4900 ppm. The pilot plant data covered an inlet SO_2 range of 400 to 4600 ppm.

The coefficient α_7 in Table 7-1 for cases other than TCA with limestone should be regarded as less accurate simply because of the narrow range of the run-average values of inlet SO_2 concentration available for these cases. Therefore, for these other cases, caution should be exercised when extrapolating the inlet SO_2 concentration beyond the narrow range of 2300 to 3500 ppm indicated abcve.

The chloride term, α_8 Cl, for the spray tower with lime (see Table 7-1) was required to explain higher percent SO_2 removal in factorial testing (at 5000 to 13,000 ppm chloride) than in long-term testing (at 1000 to 7000 ppm chloride). The chloride term increases the percent of the variation explained for the overall spray tower lime data from 65 percent to 82 percent. However, such effect was not noted in the other three cases. Further work is needed in this area to substantiate the effect of chloride on pH and SO_2 removal postulated in Section 3.2.6.

FIGURE 7-1.

PREDICTED (EQUATION 7-7) VERSUS

MEASURED SO_2 REMOVAL - TCA WITH LIMESTONE

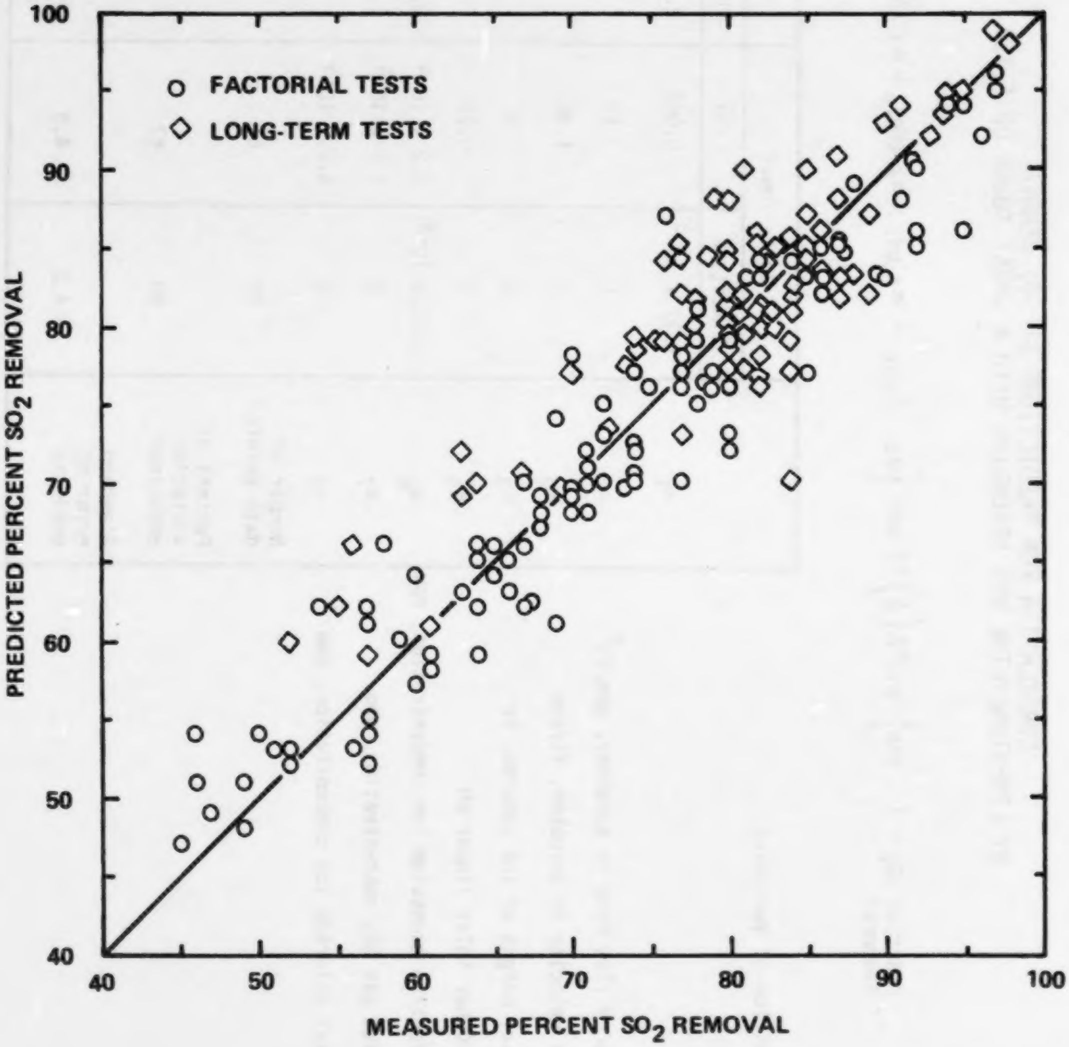


Table 7-1

CORRELATION FOR PREDICTIONS OF SO_2 REMOVAL BY LIMESTONE/LIME WET SCRUBBING WITH A SPRAY TOWER OR A TCA

$$\text{Fraction } SO_2 \text{ Removal} = 1 - \exp\left\{-\alpha_1 L^{\alpha_2}\left(\frac{1}{v}\right)^{\alpha_3} \exp\left[\alpha_4 \; h_{tot} + \alpha_5 \, pH_i + \alpha_6 \, (Mg)_e - \alpha_7 \, (SO_2)_i + \alpha_8 \, Cl\right]\right\}$$

Definition of Variables

L = slurry flow rate in scrubber, gpm/ft^2

v = gas velocity in scrubber, ft/sec

h_{tot} = total height of TCA spheres, in

pH_i = scrubber inlet liquor pH

$(Mg)_e$ = effective magnesium ion concentration, ppm

$(SO_2)_i$ = inlet gas SO_2 concentration, ppm

Cl = total chloride ion concentration, ppm

	Spray Tower		TCA	
	Limestone	Lime	Limestone	Lime
α_1	1.37×10^{-3}	0.082	2.0×10^{-3}	0.0187
α_2	1	1	0.71	1
α_3	1	1.36	0	0
α_4	0	0	0.030	0.026
α_5	1	0.29	0.72	0.16
α_6	1.25×10^{-4}	3.2×10^{-4}	8.4×10^{-5}	1.6×10^{-4}
α_7	0	9.5×10^{-5}	1.5×10^{-4}	2.9×10^{-4}
α_8	0	5.2×10^{-5}	0	0
Number of data points	77	64	182	54
Percent of variation explained	90	82	88	93
Standard error of estimate	4.2	4.5	4.3	3.6

For design purposes pH values used in the correlations should not exceed 5.6 for the spray tower with limestone, 5.8 for the TCA with limestone, and 8.0 for lime. For correlated Shawnee tests at higher pH values, alkali stoichiometries (uncontrolled) were often high enough to result in scaling problems for long-term operation.

7.3 PARAMETRIC PLOTS DERIVED FROM THE CORRELATIONS

Figures 7-2 through 7-9 show predictions of SO_2 removal by the correlations in Table 7-1 (constants for Equation 7-7 fitted to Shawnee data) for an inlet SO_2 concentration of 2500 ppm, and for other operating conditions as indicated on the figures.

Figure 7-2 shows the effects of slurry flow rate and total height of spheres on SO_2 removal for the TCA with limestone operating at a high inlet liquor pH of 5.8 without additives. For a total sphere height of 15 inches, an increase in slurry flow rate from 20 to 40 gpm/ft^2 increases SO_2 removal from about 70 to about 85 percent, thus reducing SO_2 emission by a factor of two. At a slurry flow rate of 30 gpm/ft^2, increasing the total height of spheres from zero to 22.5 inches increases SO_2 removal from about 65 to about 85 percent, reducing SO_2 emission by more than a factor of two.

Figure 7-3 presents the effects of scrubber inlet liquor pH on SO_2 removal for the TCA with limestone, 15 inches of spheres, and no additive. Slurry flow rate is shown as a parameter. For a slurry flow rate of 30 gpm/ft^2, an increase in scrubber inlet pH from 5.2 to 5.8 increases SO_2 removal from about 65 percent to about 80 percent.

FIGURE 7-2.

PREDICTED (EQUATION 7-7) SO_2 REMOVAL AS A FUNCTION OF SLURRY FLOW RATE AND TOTAL HEIGHT OF SPHERES - TCA WITH LIMESTONE

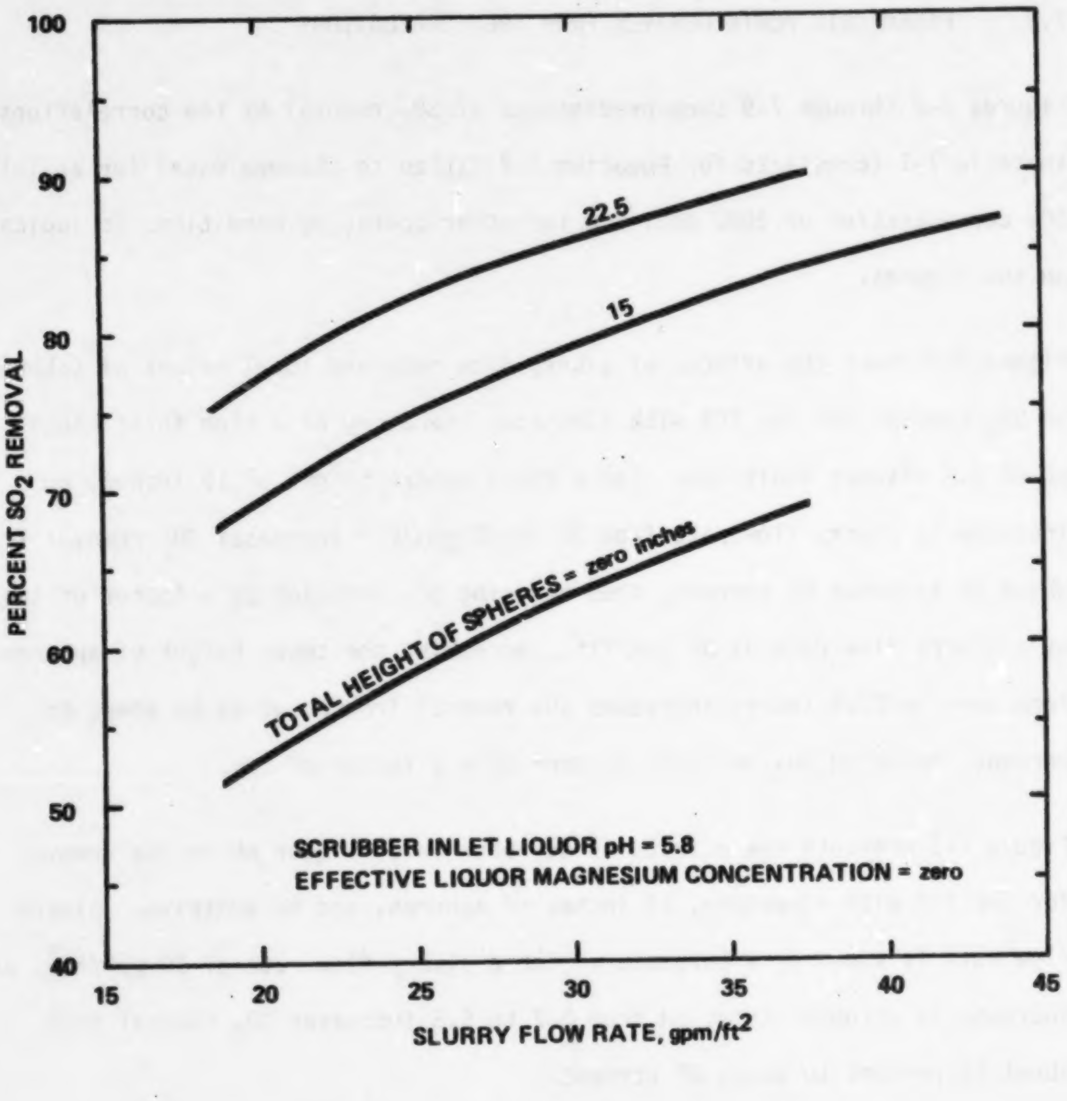


FIGURE 7-3.

PREDICTED (EQUATION 7-7) SO_2 REMOVAL AS A FUNCTION OF SCRUBBER INLET LIQUOR pH AND SLURRY FLOW RATE - TCA WITH LIMESTONE

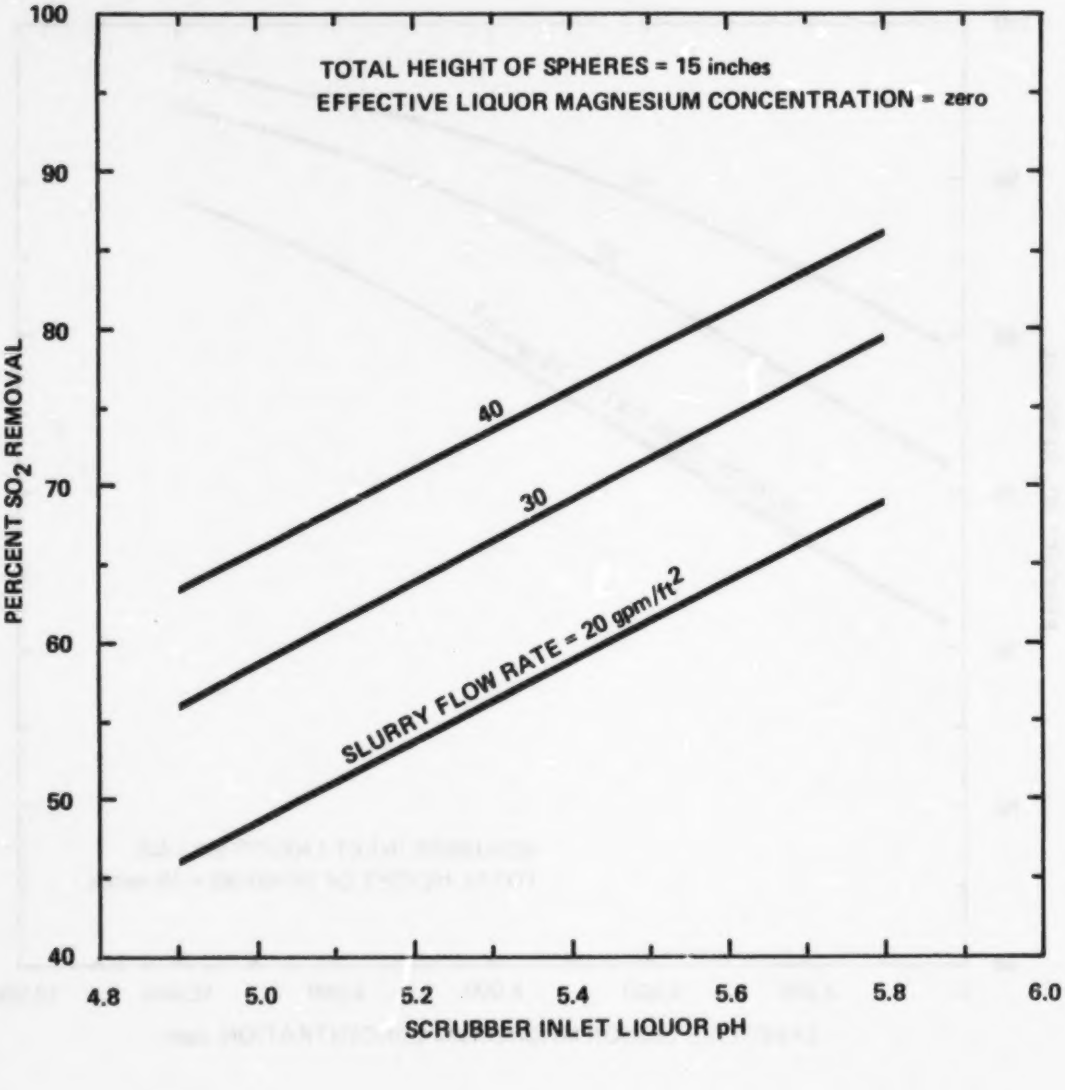


FIGURE 7-4.

PREDICTED (EQUATION 7-7) SO_2 REMOVAL AS A FUNCTION OF EFFECTIVE LIQUOR MAGNESIUM CONCENTRATION AND SLURRY FLOW RATE - TCA WITH LIMESTONE

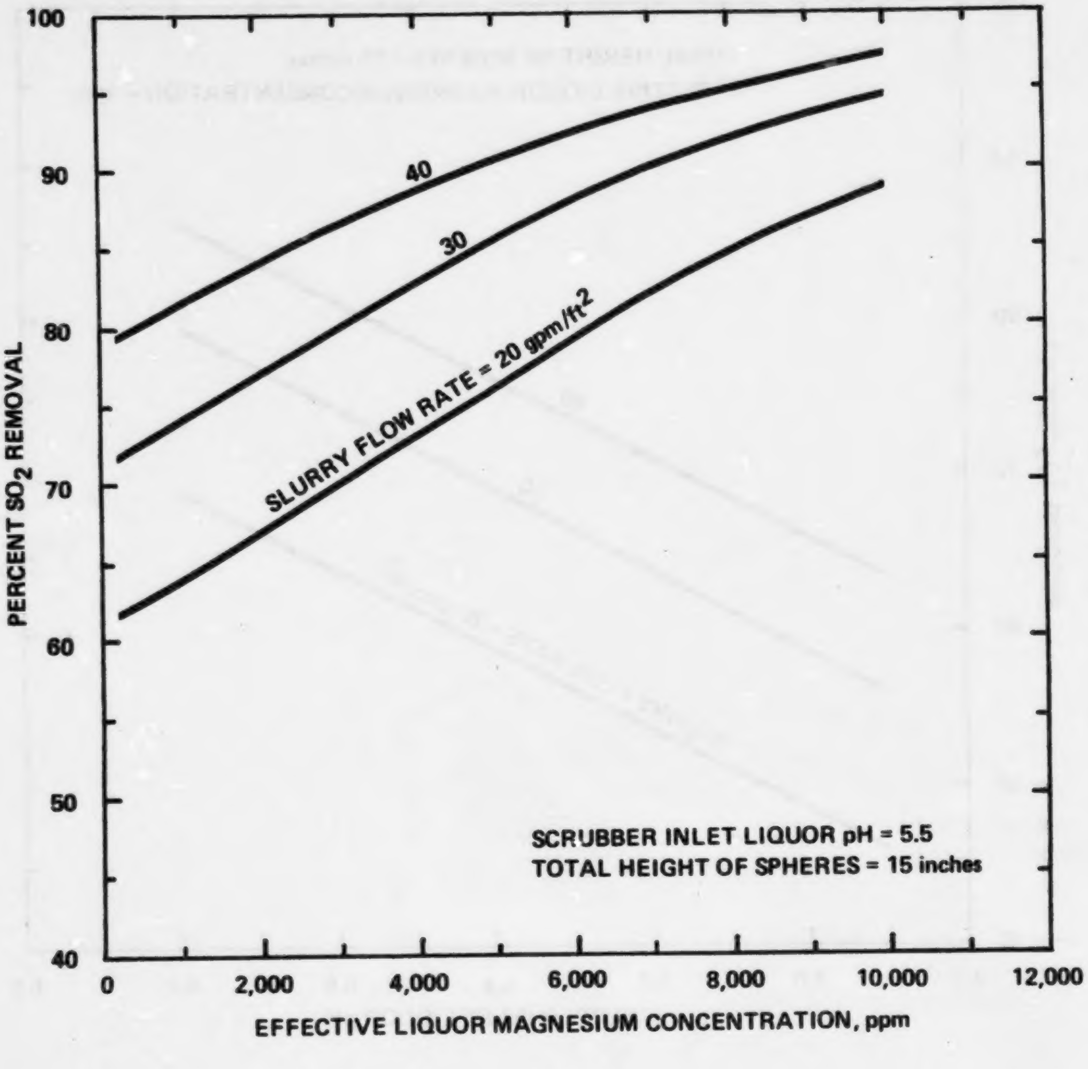


FIGURE 7-5.

PREDICTED (EQUATION 7-7) SO_2 REMOVAL AS A FUNCTION OF LIQUID-TO-GAS RATIO AND SCRUBBER INLET LIQUOR pH - SPRAY TOWER WITH LIMESTONE

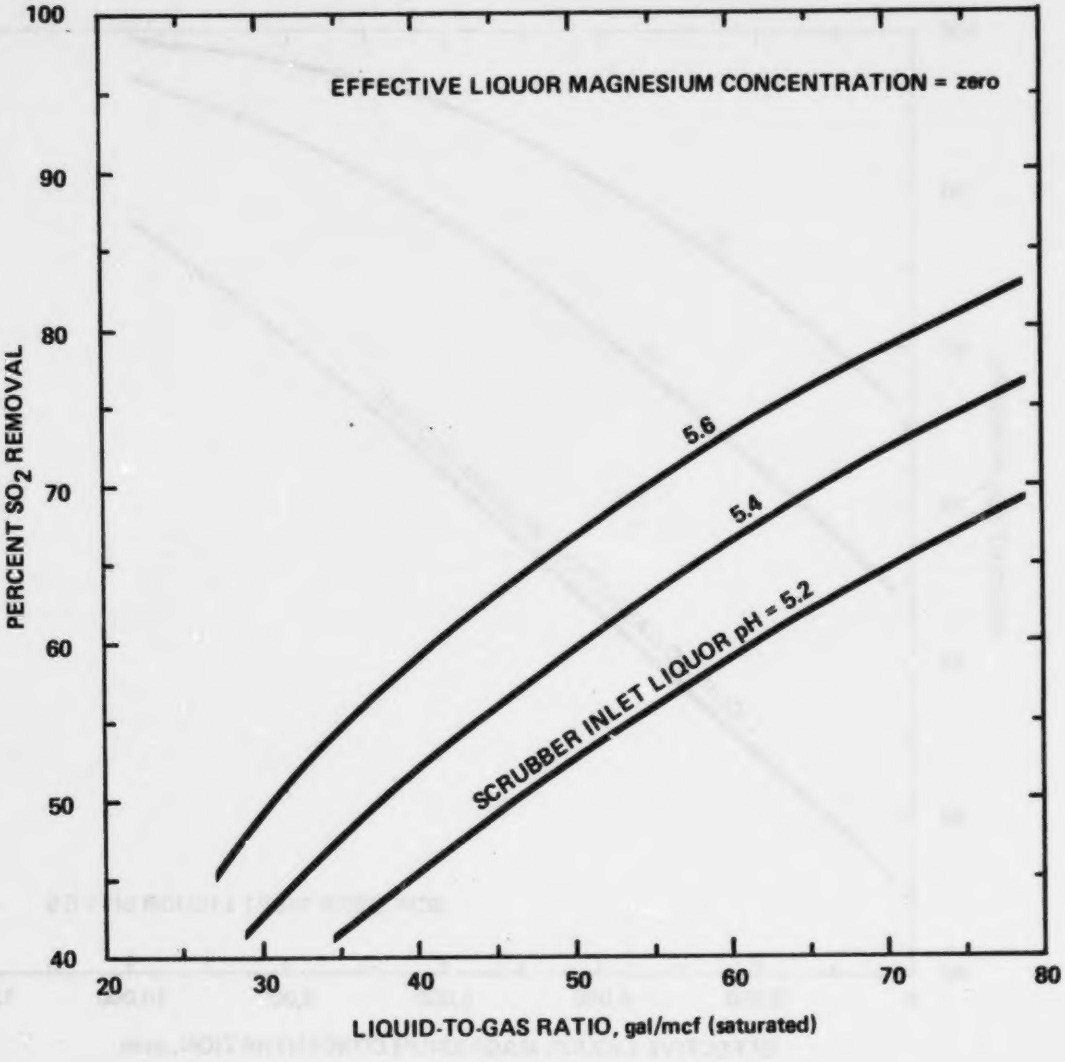


FIGURE 7-6.

PREDICTED (EQUATION 7-7) SO_2 REMOVAL AS A FUNCTION OF EFFECTIVE LIQUOR MAGNESIUM CONCENTRATION AND LIQUID-TO-GAS RATIO - SPRAY TOWER WITH LIMESTONE

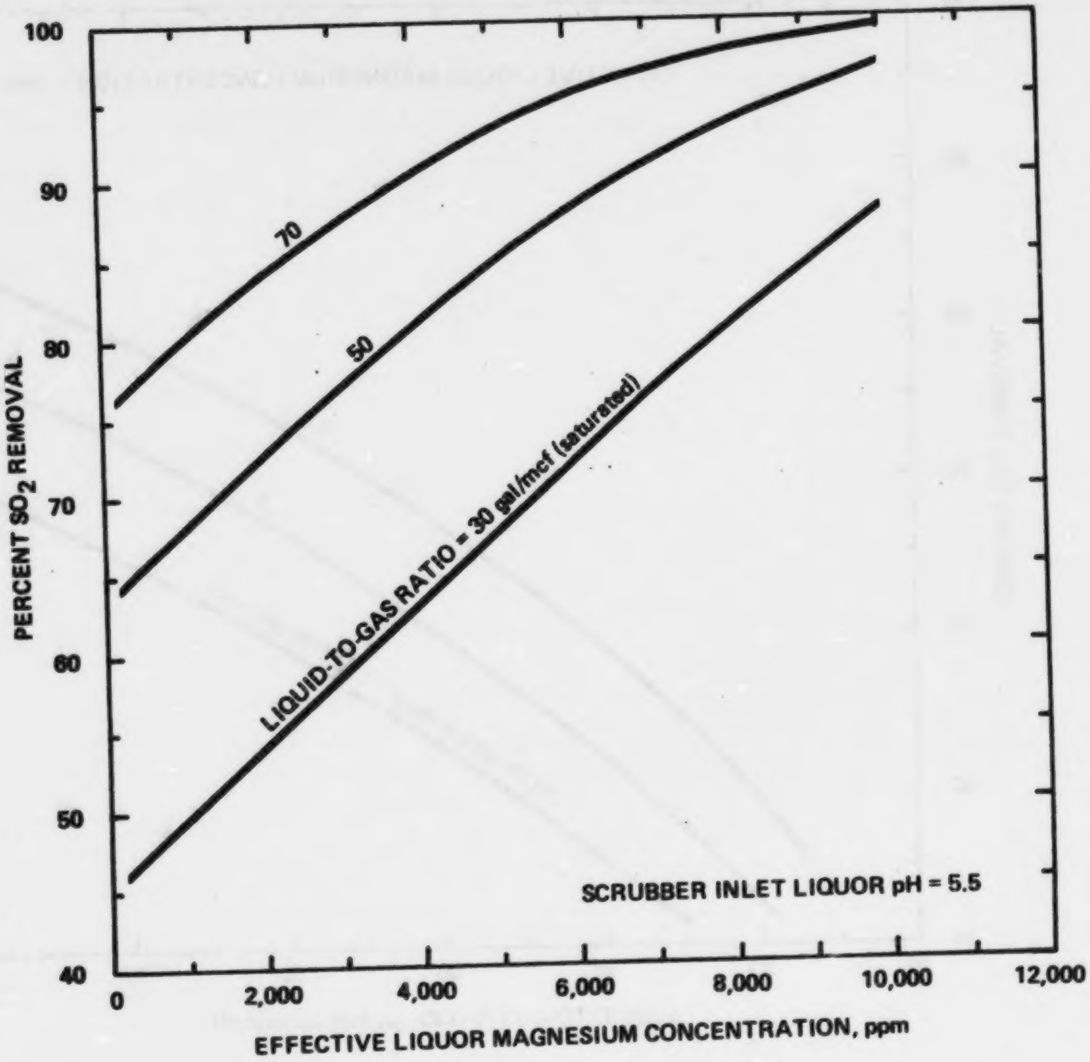


FIGURE 7-7.

PREDICTED (EQUATION 7-7) SO_2 REMOVAL AS A FUNCTION OF SCRUBBER INLET LIQUOR pH AND SLURRY FLOW RATE - TCA WITH LIME

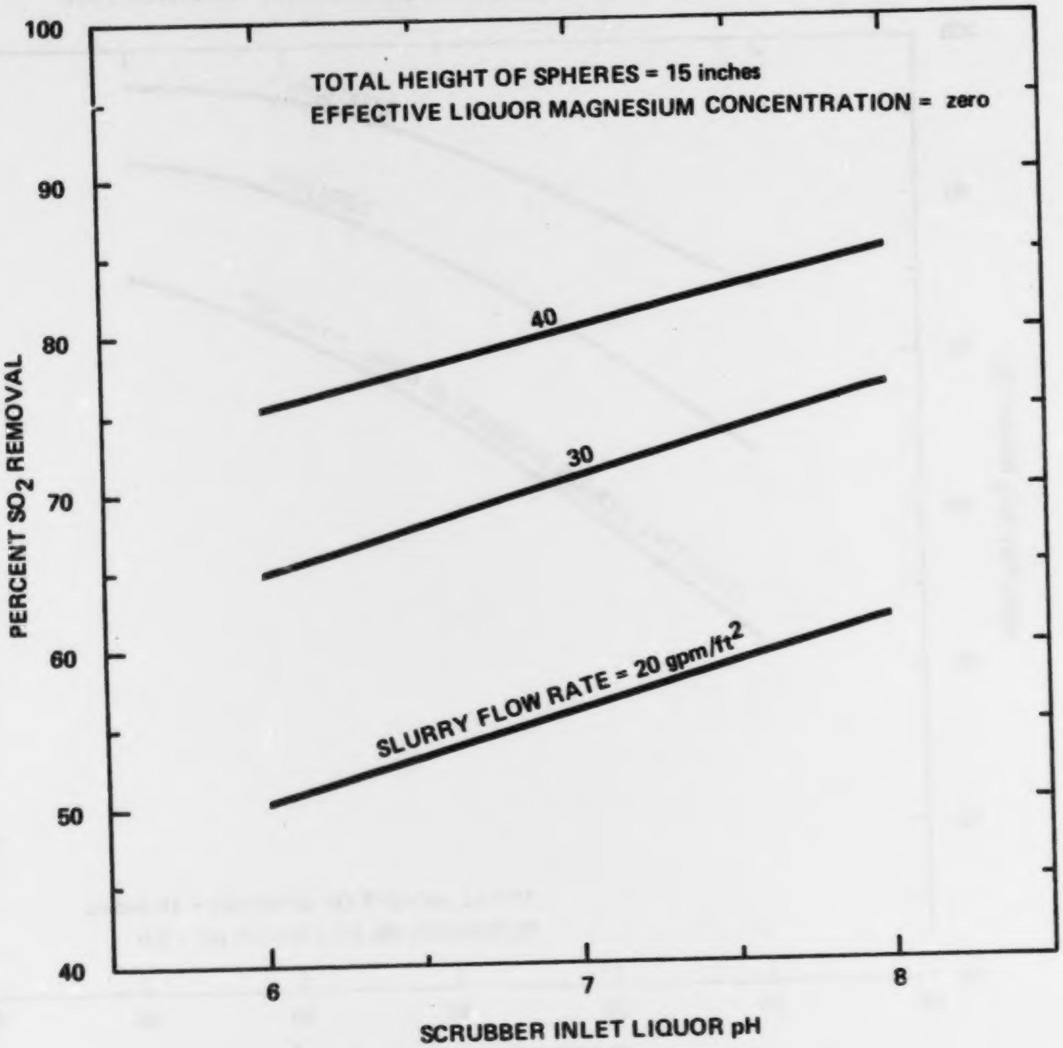


FIGURE 7-8.

PREDICTED SO_2 REMOVAL AS A FUNCTION OF SLURRY FLOW RATE AND EFFECTIVE LIQUOR MAGNESIUM CONCENTRATION - TCA WITH LIME

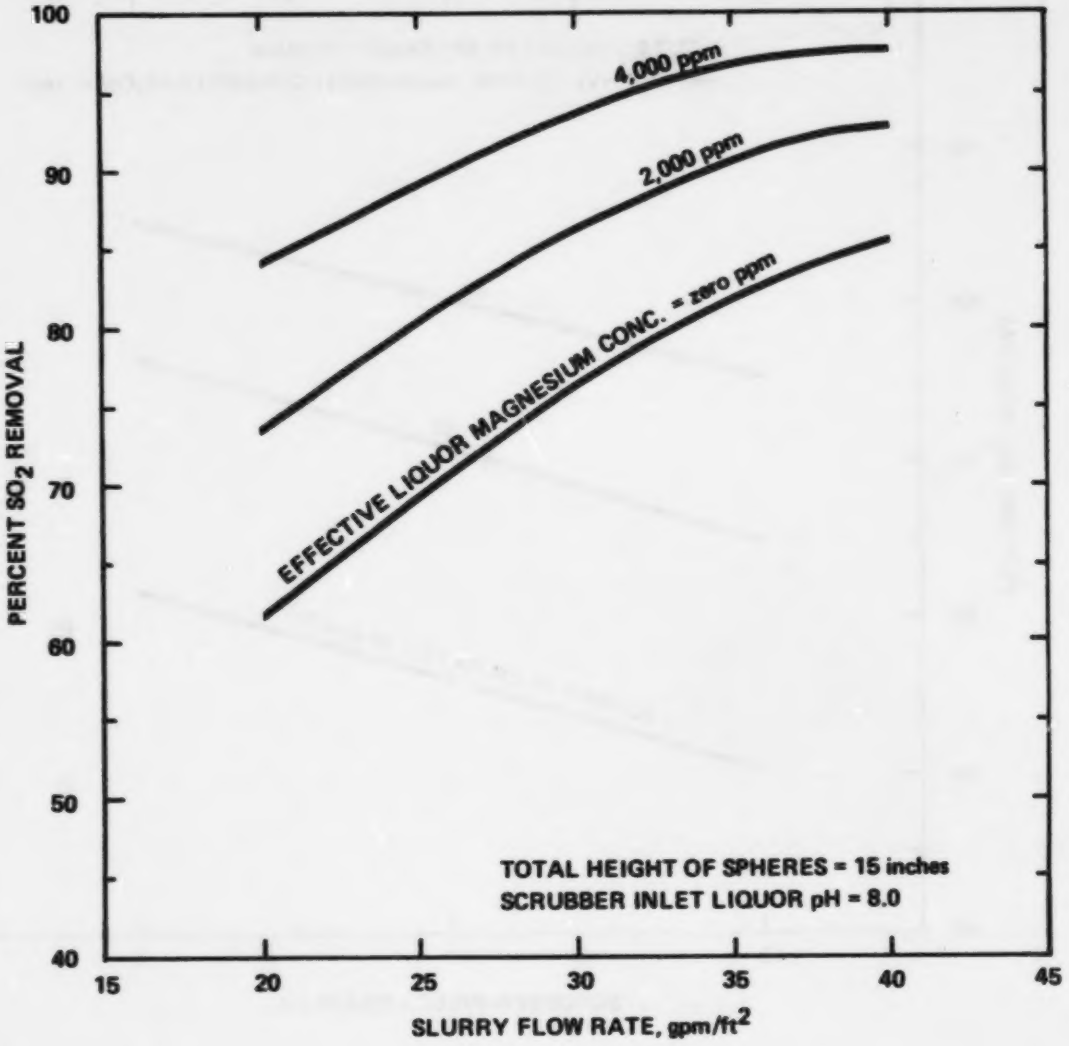


FIGURE 7-9.

PREDICTED (EQUATION 7-7) SO_2 REMOVAL AS A FUNCTION OF SCRUBBER INLET LIQUOR pH AND LIQUID-TO-GAS RATIO - SPRAY TOWER WITH LIME

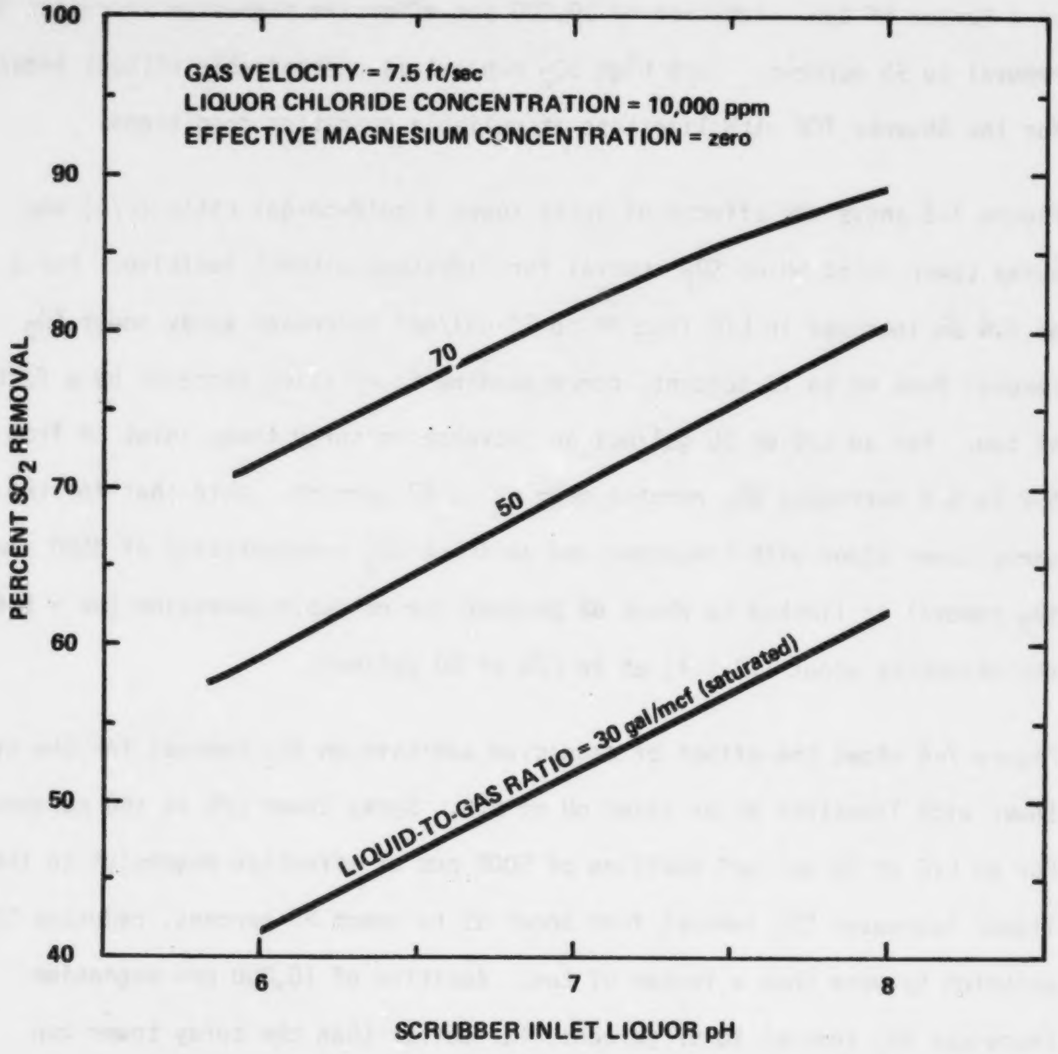


Figure 7-4 shows the effect of magnesium additive on SO_2 removal for the TCA with limestone, scrubber inlet pH of 5.5, and a total sphere height of 15 inches. Slurry flow rate is the parameter. For a slurry flow rate of 30 gpm/ft^2, the addition of 5000 ppm effective magnesium to the scrubber liquor increases SO_2 removal from about 70 to about 85 percent, cutting SO_2 emission by a factor of two. Addition of 10,000 ppm effective magnesium increases SO_2 removal to 95 percent. Such high SO_2 removal is unattainable without additive for the Shawnee TCA with limestone at reliable operating conditions.

Figure 7-5 shows the effects of spray tower liquid-to-gas ratio (L/G) and spray tower inlet pH on SO_2 removal for limestone without additive. For a pH of 5.4 an increase in L/G from 30 to 70 gal/mcf increases spray tower SO_2 removal from 42 to 72 percent, corresponding to emission decrease by a factor of two. For an L/G of 50 gal/mcf an increase in spray tower inlet pH from 5.2 to 5.6 increases SO_2 removal from 52 to 67 percent. Note that for the spray tower alone with limestone and an inlet SO_2 concentration of 2500 ppm, SO_2 removal is limited to about 83 percent for reliable operation (pH = 5.6, stoichiometry about 1.3-1.4) at an L/G of 80 gal/mcf.

Figure 7-6 shows the effect of magnesium additive on SO_2 removal for the spray tower with limestone at an inlet pH of 5.5. Spray tower L/G is the parameter. For an L/G of 50 gal/mcf addition of 5000 ppm of effective magnesium to the liquor increases SO_2 removal from about 65 to about 85 percent, reducing SO_2 emission by more than a factor of two. Addition of 10,000 ppm magnesium increases SO_2 removal to 97 percent, far better than the spray tower can achieve without additive even at very high L/G and stoichiometry.

Figure 7-7 shows the effect of TCA inlet liquor pH on SO_2 removal with lime at a total sphere height of 15 inches. The parameter is slurry flow rate. For a slurry flow rate of 30 gpm/ft^2 an increase in pH from 6.0 to 8.0 increases SO_2 removal from 65 to 77 percent.

Figure 7-8 shows the effects of slurry flow rate and effective magnesium concentration on SO_2 removal for the TCA with lime, an inlet pH of 8.0, and a total sphere height of 15 inches. With no magnesium additive an increase in slurry flow rate from 20 to 40 gpm/ft^2 increases SO_2 removal from about 60 to 85 percent, cutting SO_2 emission by a factor of two and a half. This is slightly stronger than the corresponding effect with limestone (see Figure 7-2).

For a slurry flow rate 30 gpm/ft^2 addition of 2000 ppm effective magnesium increases SO_2 removal from 76 to 86 percent; addition of 4000 ppm effective magnesium increases the removal to 94 percent. Thus for the TCA, magnesium additive is even more effective with lime than with limestone (compare Figure 7-8 with Figure 7-4).

Figure 7-9 shows the effects of spray tower inlet pH and L/G on SO_2 removal for lime alkali. The curves correspond to those predicted from Table 7-1 with a chloride concentration of 10,000 ppm and a gas velocity of 7.5 ft/sec, average values for the spray tower lime factorial runs.* For an L/G of 50 gal/mcf an increase in spray tower inlet pH from 6.0 to 8.0 increases SO_2 removal from about 60 percent to 80 percent, cutting emission by a factor of two. The lime pH effect for the spray tower is stronger than that for the TCA (see Figure 7-7).

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* It is recommended that these values of gas velocity = 7.5 ft/sec and chloride = 10,000 ppm be used by anyone using Equation 7-7 as correlated in Table 7-1 for design of a spray tower lime scrubbing system. The effects of gas velocity and chloride on SO_2 removal are unverified, and are statistically far less significant than the effects of pH, liquid-to-gas ratio, and magnesium concentration.

Figure 7-9 also indicates that, for an inlet pH of 8.0, increasing the L/G from 30 to 70 gal/mcf increases SO_2 removal from 62 percent to nearly 90 percent, reducing SO_2 emission by almost a factor of four.

Section 8

CALCULATION OF GYPSUM SATURATION

Monitoring of gypsum (calcium sulfate dihydrate) saturation is important because Shawnee testing has demonstrated that scaling usually occurs whenever the saturation exceeds about 135 percent. This section presents simplified equations for the calculation of gypsum saturation from the measured concentrations of calcium, magnesium, and sulfate ions. These equations were fitted to the predictions of gypsum saturation made by the Bechtel-Modified Radian Equilibrium Computer Program (Reference 1) for liquors sampled from the Shawnee lime and limestone long-term reliability tests. These equations are used to calculate the gypsum saturation in the Shawnee database.

Equations 8-1 and 8-2 predict the degree of gypsum saturation in lime/limestone wet-scrubbing liquors, at 25 and 50°C, respectively. The equations have been fitted to results from the Bechtel-Modified Radian Equilibrium Computer Program.

At 25°C:

$$\text{Fraction Gypsum Saturation} = (\text{Ca})\,(\text{SO}_4)\left[\frac{300}{I} + 76\right] \qquad (8\text{-}1)$$

At 50°C:

$$\text{Fraction Gypsum Saturation} = (\text{Ca})\,(\text{SO}_4)\left[\frac{263}{I} + 47\right] \qquad (8\text{-}2)$$

where

$$I = 3\,[(\text{Ca}) + (\text{Mg})] + (\text{SO4}) \qquad (8\text{-}3)$$

= ionic strength of the liquor (g-mole/l), assuming the liquor contains only Ca^{++}, Mg^{++}, $\text{SO}_4^{=}$, and Cl^{-} ions in solution.*

(Ca)
(Mg) = measured dissolved concentrations of total calcium, magnesium,
(SO_4) and sulfate, respectively, g-mole/liter.

Equations 8-1 and 8-2 can be used for simple, accurate, and convenient prediction of gypsum saturation by those not having access to the modified Radian program.

---

*From the ionic balance: $(\text{Cl}) = 2\,[(\text{Ca}) + (\text{Mg}) - (\text{SO}_4)]$. Therefore, $I = 1/2\,\Sigma M_i Z_i^2 = 1/2\,[4\,(\text{Ca}) + 4\,(\text{Mg}) + 4\,(\text{SO}_4) + (\text{Cl})] = 3\,[(\text{Ca}) + (\text{Mg})] + \text{SO}_4$, where M_i is the molarity of component i and Z_i is its unit charge. Note that K and Na concentrations are low at Shawnee and, therefore, have not been included in Equation 8-3. However, preliminary evaluation of liquor compositions from other limestone and lime installations has indicated that the effect of high dissolved sodium is accounted for by adding the dissolved Na concentration (g-mole/liter) to the ionic strength, I.

Equations 8-1 and 8-2 agree with the modified Radian program to within a standard error of about 0.04 fraction saturation for the following ranges of variables:

Liquor pH: 4.0 - 9.0

Radian-predicted fraction of gypsum saturation: 0.2 - 3.0

Dissolved concentrations (m-mole/liter):

Calcium	4 - 140
Magnesium	0 - 600
Sulfate	10 - 400
Sulfite	0 - 100
Chloride	0 - 400

To the extent that the Radian program itself is accurate, Equations 8-1 and 8-2 are sufficiently accurate for limestone/lime scrubbing liquors containing both magnesium and chloride ions up to 15,000 ppm.

Section 9

SCRUBBER CHARACTERISTICS

This section is intended to acquaint the reader with the mechanical operating characteristics of the TCA, venturi and spray tower scrubbers. The pressure drop, turndown characteristics, and ranges of operating conditions for these scrubbers are discussed. The information is taken from detailed findings presented in earlier progress reports (References 1, 2, 3, 4, and 5).

9.1 TURBULENT CONTACT ABSORBER (TCA)

9.1.1 Description

The TCA was manufactured by Universal Oil Products (UOP). It operates with up to three beds of low-density spheres, nominally 1-1/2 inches in diameter, free to move between retaining grids. As the incoming flue gas contacts the slurry in these beds, both SO_2 and particulates are removed. The cross-sectional area of the TCA scrubber is 32 ft^2, over the scrubbing section and 49 ft^2 across the mist eliminator section.

Figure 9-1 is a schematic of the scrubber. The chevron mist eliminator used during the latest testing period is depicted to scale in Figure 9-2. The TCA is capable of treating approximately 30,000 acfm (at 300°F) of flue gas from

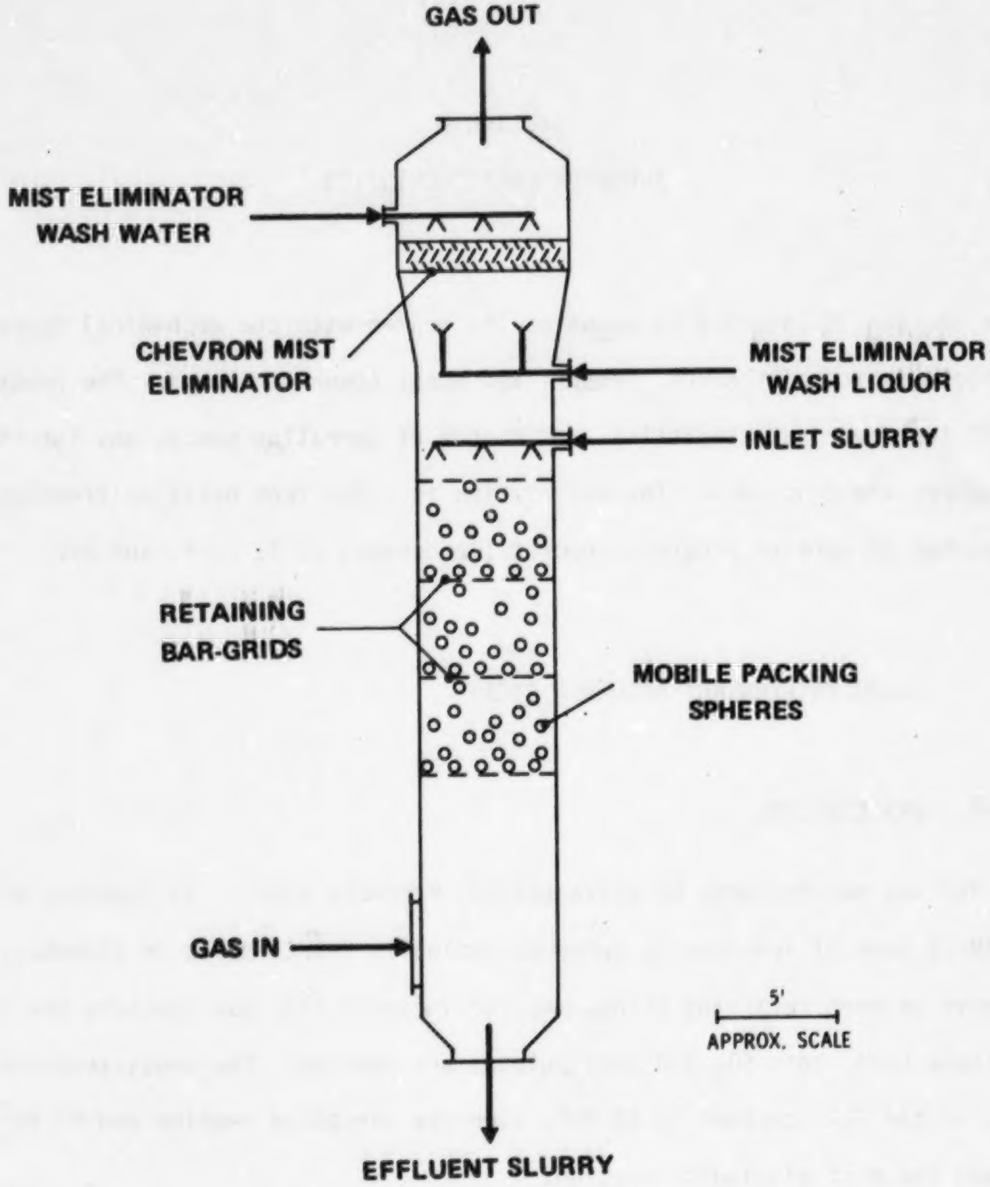
GAS OUT
MIST ELIMINATOR WASH WATER
CHEVRON MIST ELIMINATOR
MIST ELIMINATOR WASH LIQUOR
INLET SLURRY
RETAINING BAR-GRIDS
MOBILE PACKING SPHERES
GAS IN
5'
APPROX. SCALE
EFFLUENT SLURRY

Figure 9-1. Schematic of Three-Bed TCA

THREE-PASS, OPEN-VANE, 316L SS
CHEVRON MIST ELIMINATOR
(HORIZONTAL CONFIGURATION)

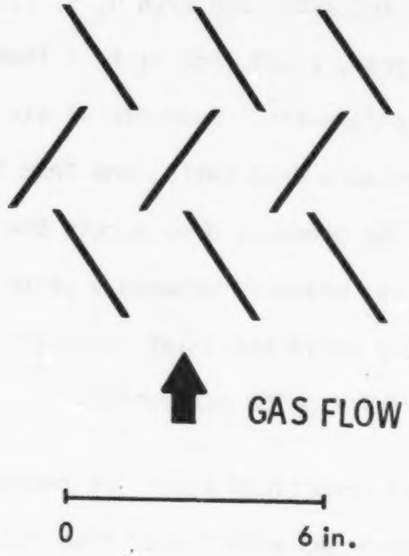

Figure 9-2. Test Facility Mist Eliminator Configuration

Boiler No. 10, approximately 10 MW of power plant capacity.

The boiler normally burns a medium to high sulfur bituminous coal producing SO_2 concentrations of 1500 to 4500 ppm in the flue gas. Ductwork connections are provided both upstream and downstream of the particulate removal equipment, allowing scrubber operation with flue gas having either high fly ash loadings (3 to 6 grains/dry scf) or low fly ash loadings (0.04 to 0.20 grain/dry scf).

9.1.2 TCA Pressure Drop and Holdup Characteristics

Pressure drop and liquid holdup tests were made during an April-June 1977 boiler outage with air and water and with 0, 5, 7.5, and 10 inches per bed (3 beds, 4 grids) of 6.5-gram, 1-5/8 inch nitrile foam spheres. Water flow rates ranged from 19 to 44 $gal/min\text{-}ft^2$. Superficial air velocities varied from 7.5 to 13 ft/sec in the pressure drop tests, and from 0 to 11.4 ft/sec in the liquid holdup tests. The pressure drop across the three beds, including the slurry spray nozzles, was measured between a point 28 inches below the bottom bed, (35 inches directly above the inlet duct) and a point 40 inches above the top bed (see Figure 9-1 for a TCA schematic).

Results of the pressure drop/flood tests are presented in Figures 9-3 through 9-6. Pressure drop increases with liquor flow rate and air velocity. Other data collected during these tests indicated that flooding* usually occurred at 8 to 10 inches H_2O pressure drop for the three-bed TCA. Liquid holdup in the scrubber ranged from 40 to 250 gallons.

The following equation for pressure drop across the three TCA beds and four

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* Flooding is characterized by a large increase in pressure drop for a small increase in gas velocity, and by large fluctuations in pressure drop at constant gas velocity.

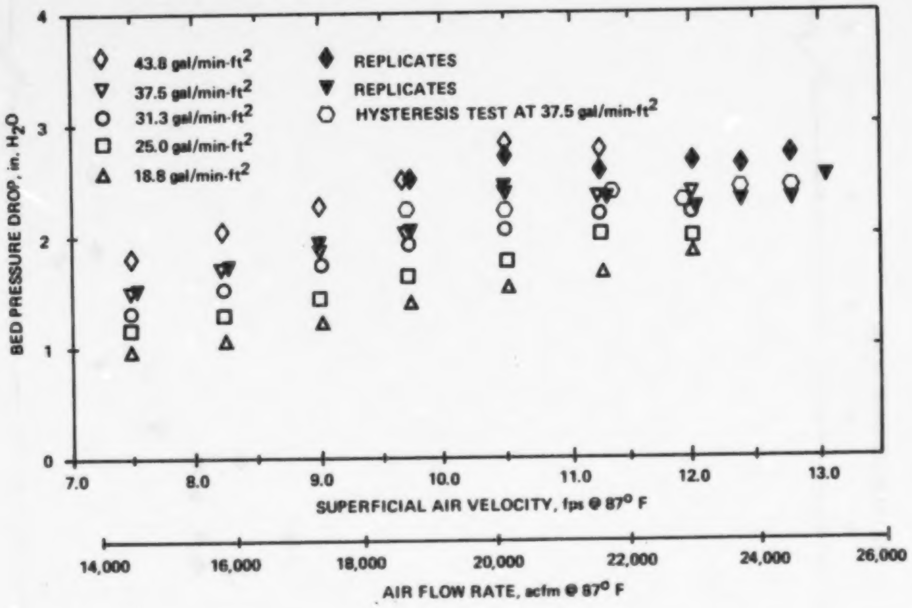

Figure 9-3. TCA Bed Pressure Drop (3 Beds, 4 Grids) - 0 inches Total Bed Height of Nitrile Foam Spheres

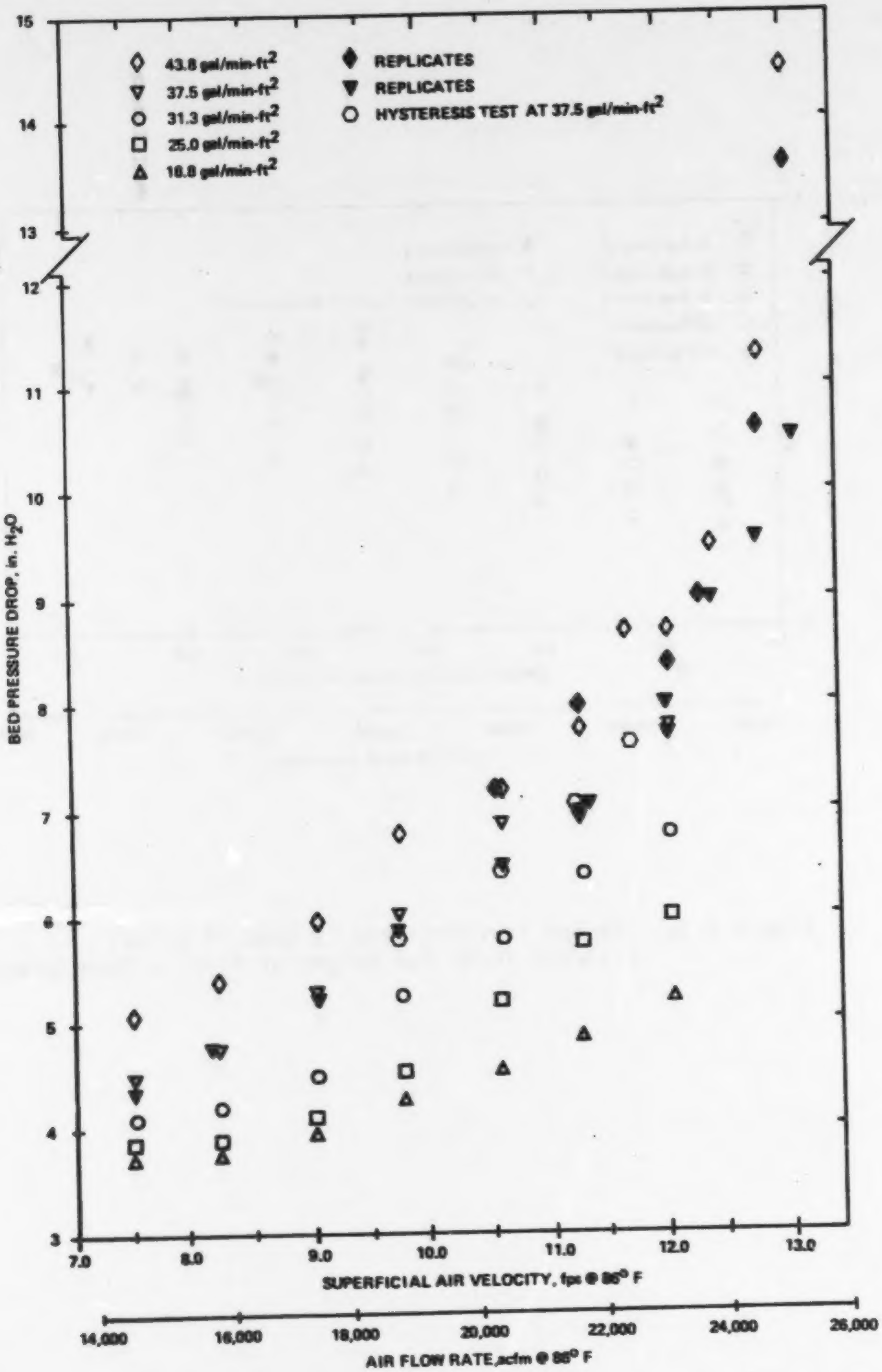

Figure 9-4. TCA Bed Pressure Drop (3 Beds, 4 Grids) - 15 inches Total Bed Height of Nitrile Foam Spheres

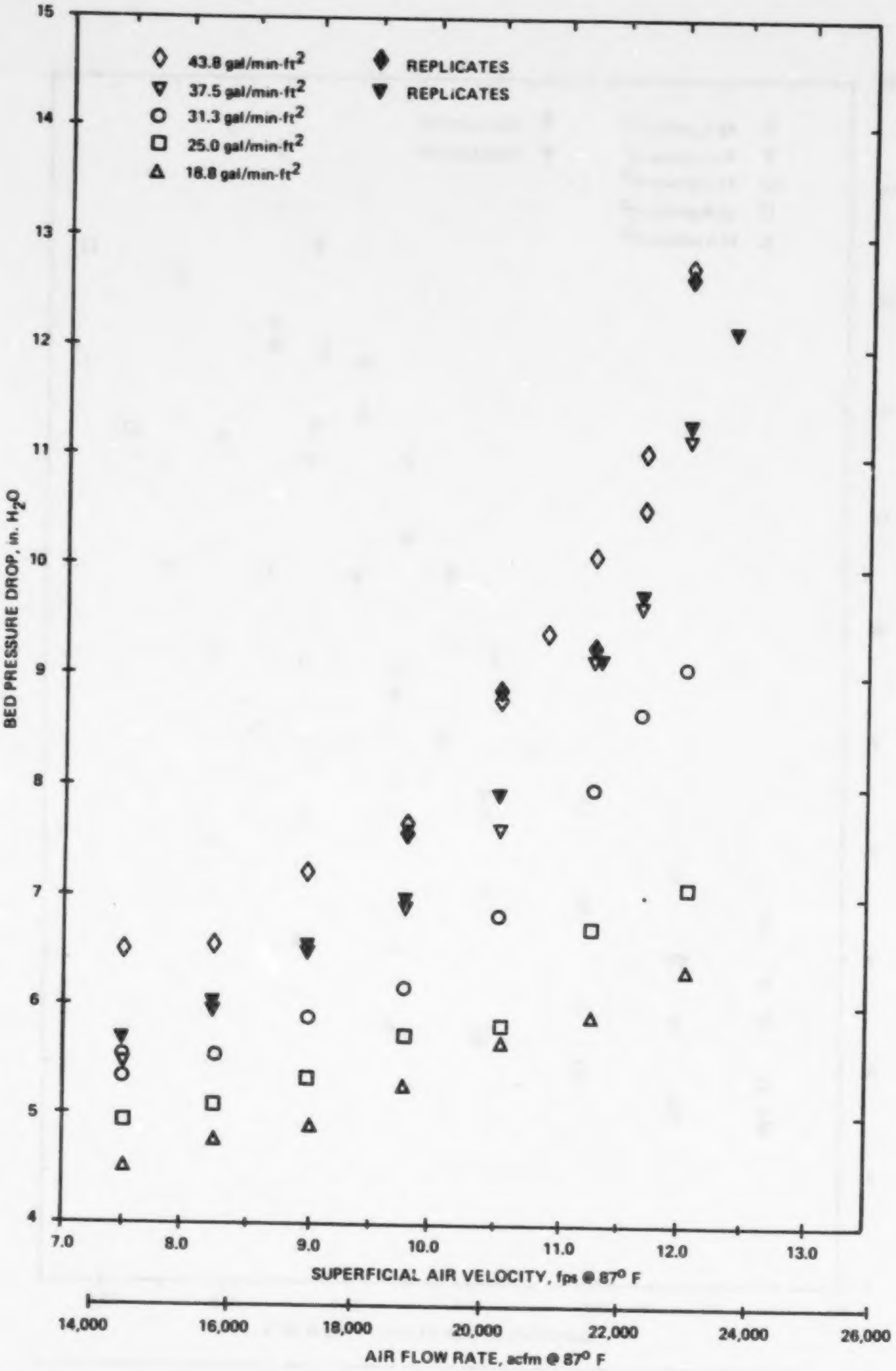

Figure 9-5. TCA Bed Pressure Drop (3 Beds, 4 Grids) - 22.5 inches Total Bed Height of Nitrile Foam Spheres

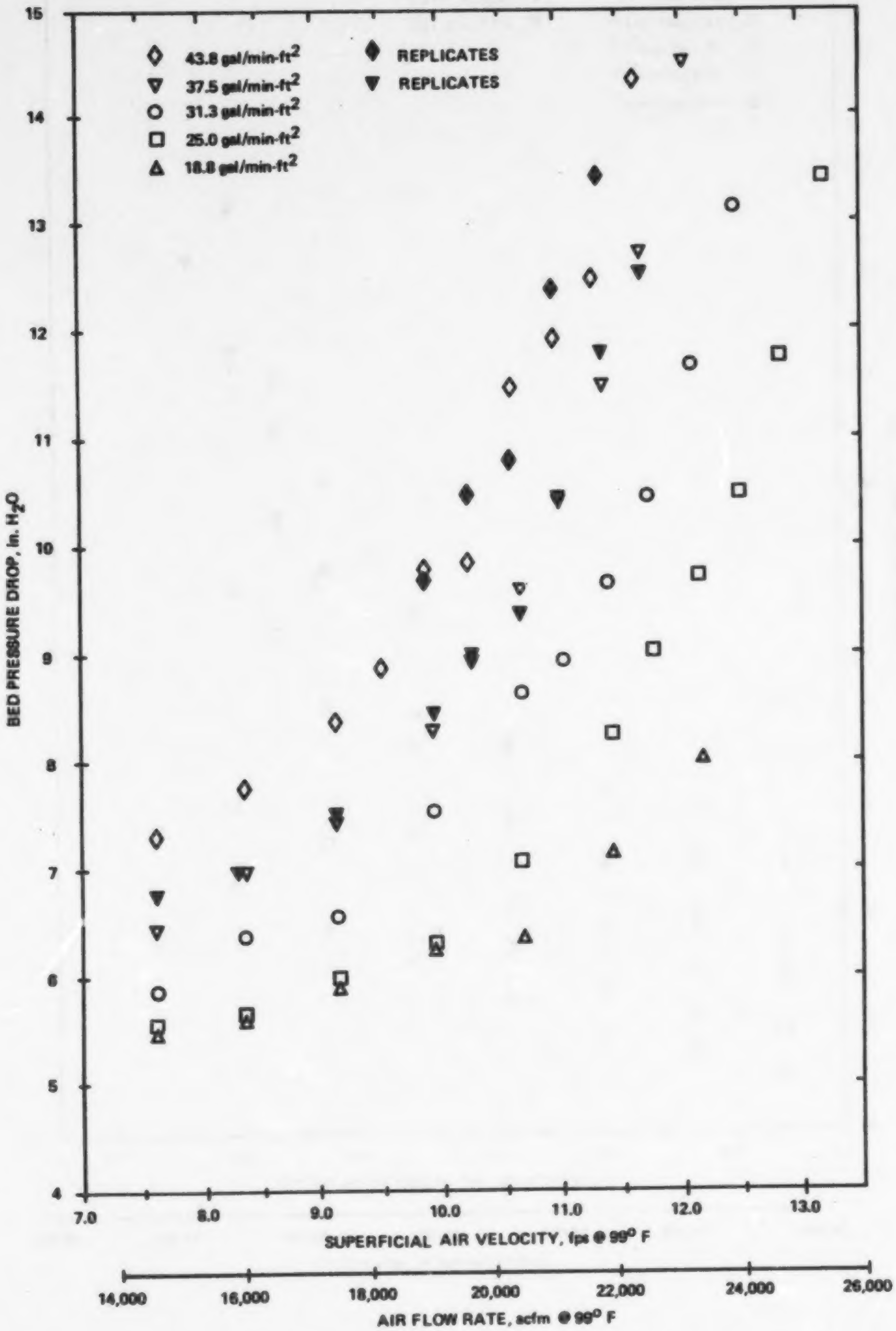

Figure 9-6. TCA Bed Pressure Drop (3 Beds, 4 Grids) - 30 inches Total Bed Height of Nitrile Foam Spheres

grids* was fitted to 164 air/water data points:

$$\Delta P = (\Delta P)_{NS} + 0.0363\ v\ H_S^{0.69}\ \exp(0.014\ L) \qquad (9\text{-}1)$$

with

$$(\Delta P)_{NS} = 0.095\ v\ \exp(0.021\ L) \qquad (9\text{-}2)$$

where:

ΔP = TCA pressure drop for three beds and four grids, in H_2O**

$(\Delta P)_{NS}$ = TCA pressure drop for four grids (no spheres), in H_2O**

v = superficial air velocity, ft/sec at 90°F

L = liquor flow rate per unit scrubber cross-sectional area, gpm/ft^2

H_S = total static bed height of 1-5/8 in. diameter 6.5-gram nitrile foam spheres, in.

The fitted ranges of the variables in Equations (9-1) and (9-2) are given below:

ΔP = 0.9 to 8.0 in. H_2O

v = 7.6 to 13.1 ft/sec

L = 19 to 44 gpm/ft^2

H_S = 0 to 30 in.

All measured pressure drops in excess of 8.0 inches H_2O were excluded from the correlation because of incipient flooding. Any case for which Equation (9-1) predicts a pressure drop greater than 8.0 inches H_2O is likely to be in the flooding region.

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* The grids consist of 3/8-in. diameter bars with a center-to-center distance of 1-1/4 inch, leaving 70 percent free area excluding support frames.

** Measured from below the bottom grid to above the top grid, including slurry spray nozzles.

Measured TCA bed pressure drops with spheres (107 data points) and the corresponding predictions from Equation (9-1) are shown in Figure 9-7. Equation (9-1) accounts for 96 percent of the variation in the data with a standard error of estimate of 0.24 inches H_2O.

Measured TCA bed pressure drops without spheres (57 data points) and the corresponding predictions from Equation (9-2) are shown in Figure 9-8. Equation (9-2) accounts for 90 percent of the variation with a standard error of 0.15 inches H_2O.

For the overall (spheres and no spheres) data, Equation (9-1) explains 99 percent of the variation with a standard error of 0.21 inches H_2O.

The form of Equation (9-1) was chosen to meet boundary constraints on pressure drop for limiting values v, L, and H_S. For example, the equation predicts zero pressure drop at zero gas velocity.

Scrubber liquid holdup ranged from 40 to 250 gallons over the range of conditions studied. Reported volumes are accurate to ± 25 gallons. The following summarizes scrubber holdup under typical operating conditions and the effect on holdup of changing major process variables:

Typical operating conditions of 11.2 ft/sec, 37.5 gal/min-ft^2, and 15 inches total sphere height	210 gallons scrubber holdup
Effect of air velocity increase from 7.5 to 11.2 ft/sec	Holdup increase by 20-60 gallons
Effect of liquor rate increase from 18.8 to 37.5 gal/min-ft^2	Holdup increase by 40-120 gallons
Effect of sphere height increase from 0 to 30 inches	Holdup increase by 70-110 gallons

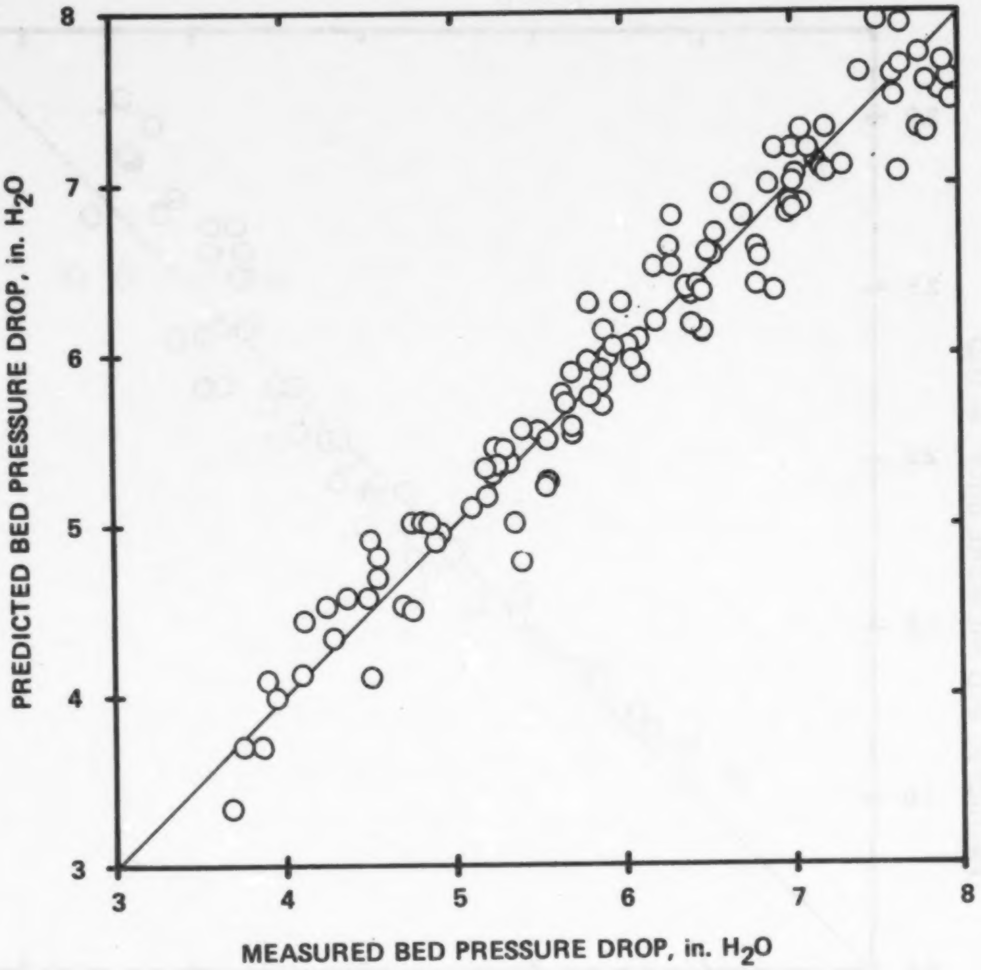

Figure 9-7. **COMPARISON OF EXPERIMENTAL DATA AND PREDICTED VALUES OF BED PRESSURE DROP – THREE-STAGE TCA WITH 1-5/8 inch DIA., 6.5 gram SOLID NITRILE FOAM SPHERES**

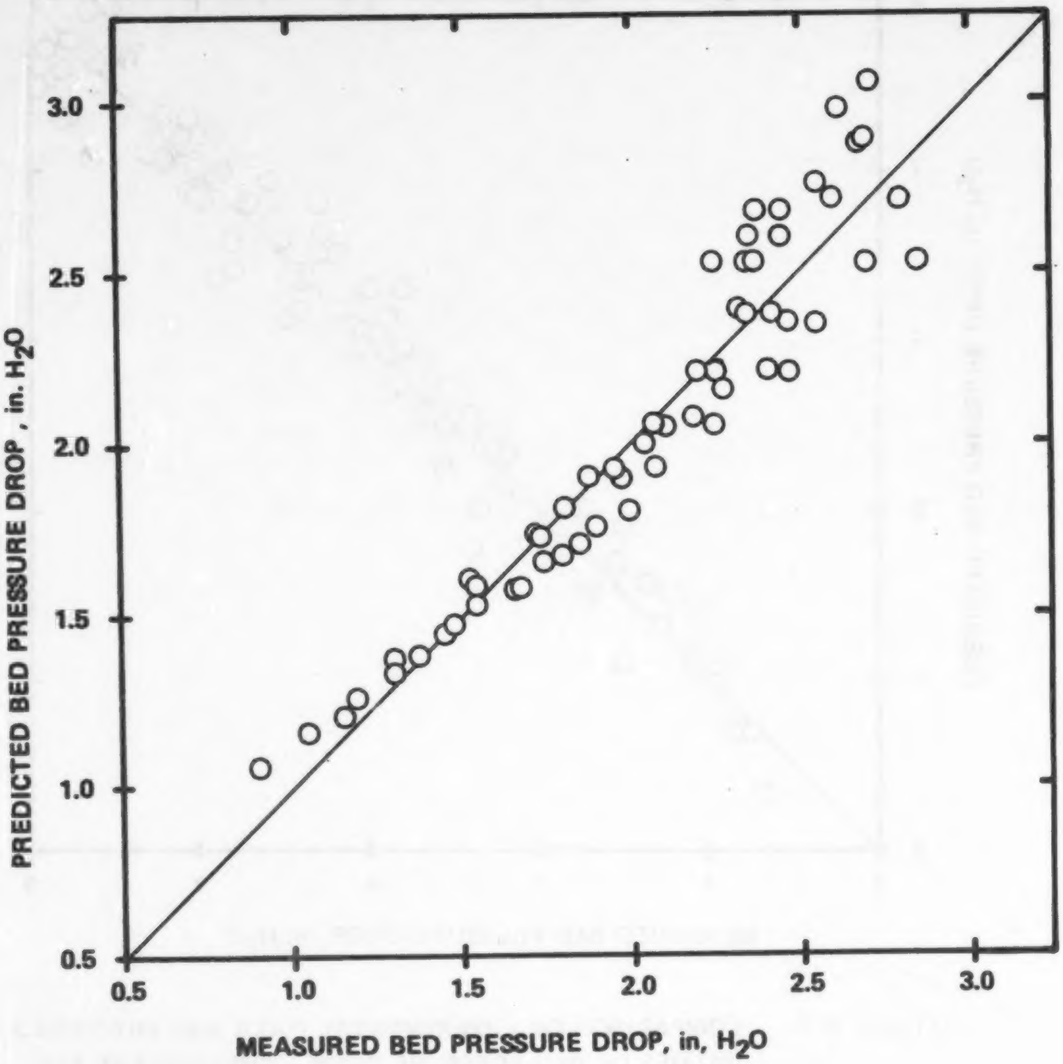

Figure 9-8. **COMPARISON OF EXPERIMENTAL DATA AND PREDICTED VALUES OF BED PRESSURE DROP – THREE-STAGE TCA WITHOUT SPHERES**

9.1.3 TCA Turndown

In the TCA it has been shown repeatedly that variation in the flue gas flow rate (gas velocity) does not significantly affect the SO_2 removal at a constant slurry flow rate. Although the liquid-to-gas ratio increases when the gas velocity is reduced, the gain in SO_2 removal from higher liquid-to-gas ratio is offset by the decreased sphere activity.

Because of the decreased sphere activity, prolonged operation of the TCA at reduced gas velocity will result in caking of the spheres, especially under conditions that give high scaling potential. Decreased sphere activity could also result in channeling. The possibility of flue gas channeling is known to be higher for larger units; uniform flow is harder to maintain where the ratio of the scrubber diameter to the depth of sphere bed is greater. Therefore caution should be used in extrapolating to larger units the observed flatness of SO_2 removal response to change in gas velocity.

9.1.4 Spheres and Sphere Life

During more than six years of testing on the TCA, (March 1972 through June 1978) several types of spheres were tested and evaluated for performance and reliability. All spheres tested at Shawnee were purchased from Universal Oil Products (UOP).

The original batch of spheres supplied with the scrubber were 1-1/2 inch polypropylene and polyethylene plastic spheres. Wear data on these indicated a weight loss of about 27 percent after approximately 1000 hours of operation. Continued erosion of the sphere shell resulted in the eventual collapse of these spheres and subsequent filling with slurry. These heavier slurry-filled spheres settled to the bottom of the support grids, where they became immobile.

The next batch of spheres consisted of the 5-gram thermoplastic rubber (TPR) spheres and high density polyethylene (HDPE) spheres. After 500 hours of operation the TPR spheres lost about 2.6 percent of their original weight and the HDPE spheres lost from 8 to 14 percent (as contrasted with an original supplier's estimate for HDPE sphere life of approximately 2000 hours). About one percent of the TPR spheres came apart at the seams. Continued operation for approximately 2500 hours with the TPR spheres resulted in dimpling on one side, about 2.4 percent seam failure, and an average weight loss of about 6 percent. Dimpled spheres, because of the reduced diameter, tended to fall through the retaining bar grids.

The 5-gram TPR and HDPE spheres were replaced with 6-gram TPR spheres. Although these heavier TPR spheres were expected to reduce the dimpling previously experienced with 5-gram spheres, a significant reduction did not occur. The failure rate for the 6-gram TPR spheres is plotted in Figure 9-9. After 3800 hours of testing approximately 11 percent of the spheres had failed from splitting at the seams. The average weight losses for the unsplit spheres in each bed were 12.0 percent at the top, 9.2 percent in the middle, and 7.7 percent at the bottom. Most of the testing was performed at 12.5 ft/sec scrubber gas velocity and 15 percent solids.

All the TPR spheres were subsequently replaced with new 6.5-gram nitrile rubber solid foam spheres. After 240 hours of operation a sample was removed and examined. The spheres still had their original color and looked clean, although they had lost their smooth, new appearance. The surfaces were slightly

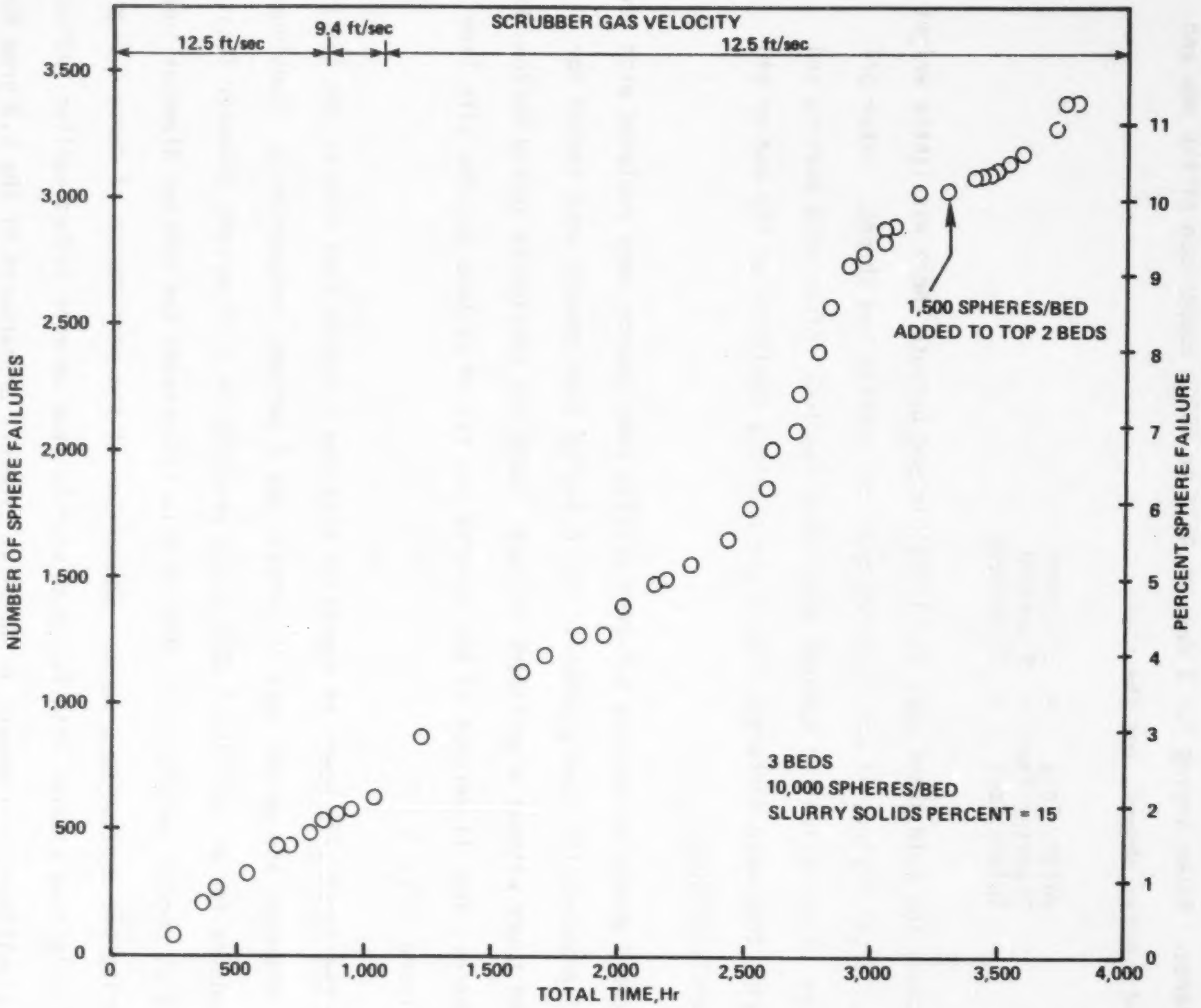

Figure 9-9. Failure Rate of 6-Gram TPR Spheres in Limestone/ Fly Ash Slurry Service

roughened, open pores were visible under a microscope, and mold seams were still apparent. They did not look wet, nor could water be squeezed from them, but prior to drying they weighed approximately 9 percent more than new, unused spheres. After drying for 3 days at 45°C to 60°C, comparison of the new and used spheres showed, for the used:

Weight loss = 1 percent
Diameter loss = 9 percent
Volume loss = 25 percent

Because the mold seams were still visible and because there was little weight loss after drying, it was presumed that the spheres had shrunk. After 574 hours of operation the spheres were again sampled. After acid washing and drying they were unchanged from their previous condition at the end of 240 operating hours.

After 3 months of testing 6.5-gram nitrile foam spheres were replaced with new 6.3-gram nitrile foam spheres . The 6.3-gram foam spheres were tested for 3888 hours without significant failure. With the previously tested hollow TPR spheres, over 11 percent of the spheres had failed at this service life (see (Figure 9-9).

In the first 1773 hours of operation with the 6.3-gram foam spheres the losses in diameter and weight were 12 percent and 4 percent, respectively. Continued exposure for an additional 2115 hours resulted in a 23 percent diameter loss and 21 percent weight loss. Figure 9-10 illustrates the spheres diameter loss during the monitoring program. Comparison of the performance of these 6.5-gram nitrile foam spheres with 6.3-gram nitrile foam spheres tested earlier indicated a significant improvement in quality. External appearances of the 6.3-gram foam spheres before and after exposure were the same noted for the 6.5-gram spheres.

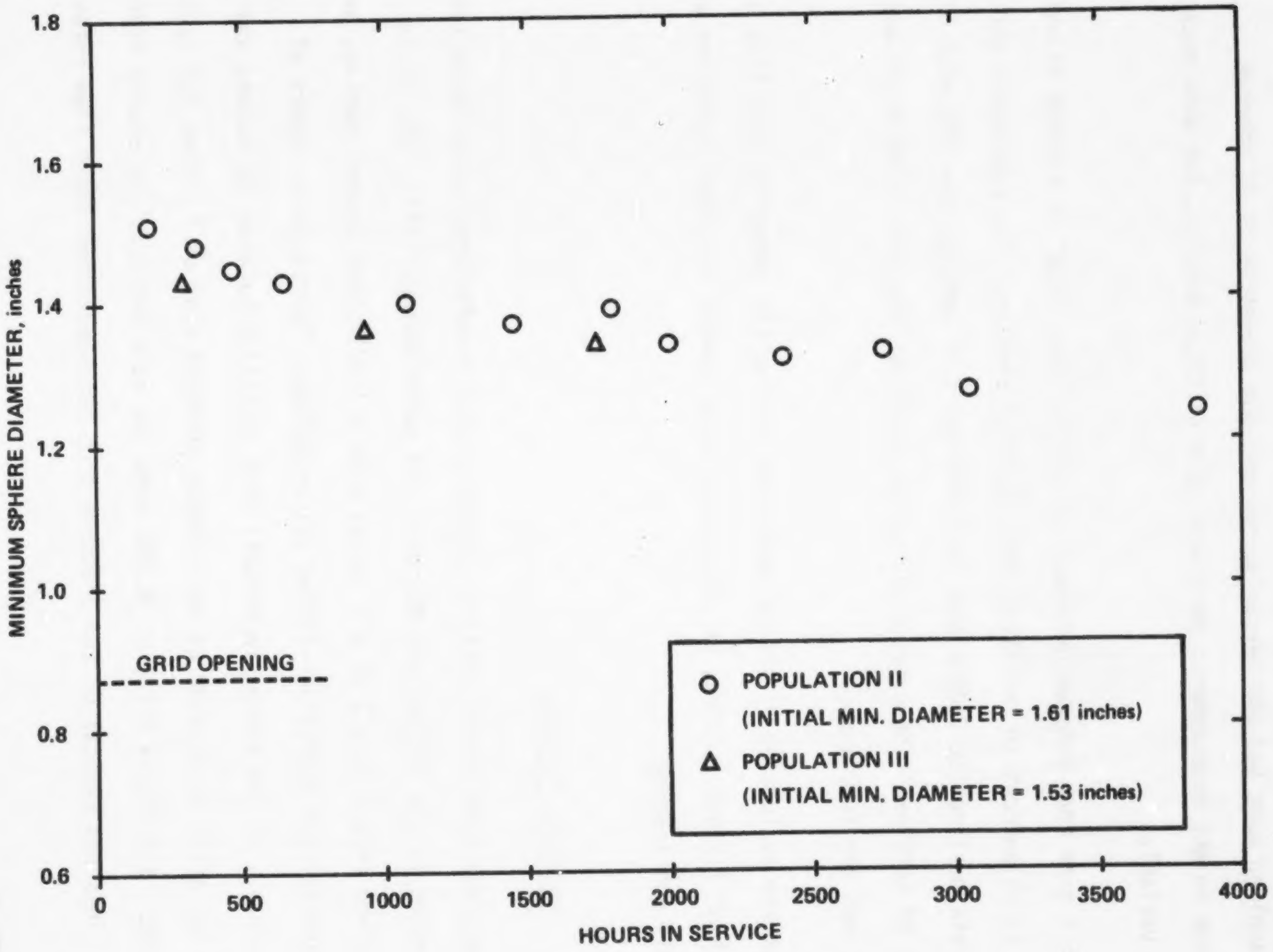

Figure 9-10. Erosion/Shrinkage Rate of Nitrile Foam Spheres

The 6.3-gram nitrile foam spheres were then replaced with improved 6.5-gram nitrile foam spheres. The wear rate on these spheres was carefully monitored by sampling each bed and measuring the minimum diameters of 25 spheres. Average weight measurements were also made of these samples, but were much more variable.

The 6.5 gram foam spheres underwent an initial shrinkage* in minimum diameters of 6 to 12 percent in the first 1000 hours of service. The subsequent shrinkage rate declined to 0.05 inches per 1000 hours of service over the next 6700 hours of service. The average shrinkage rate over the total 7700 hours was 0.07 inch per 1000 hours.

The entire evaluation of sphere wear took place while operating with flue gas with high fly ash loading, an environment more severe than when operating with low fly ash loading.

9.1.5 Ceilcote Packing

An egg-crate type plate (packing support plate) manufactured by Ceilcote Company was tested in the TCA in late November and early December 1977. The plate dimensions were 2 ft x 2 ft x 2 inches with a 1-3/16 inch square opening, and the material was fiberglass-filled polypropylene. Twenty-three layers of Ceilcote plates (46 inches in height) were installed between the second and third bar grids to provide an anticipated pressure drop of 8 inches H_2O (actual was lower, see Figure 9-11) at 30,000 acfm gas rate and 1200 gpm slurry flow rate. This was typical of the pressure drop obtained under these flow rates

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* Includes decrease in size due to abrasion.

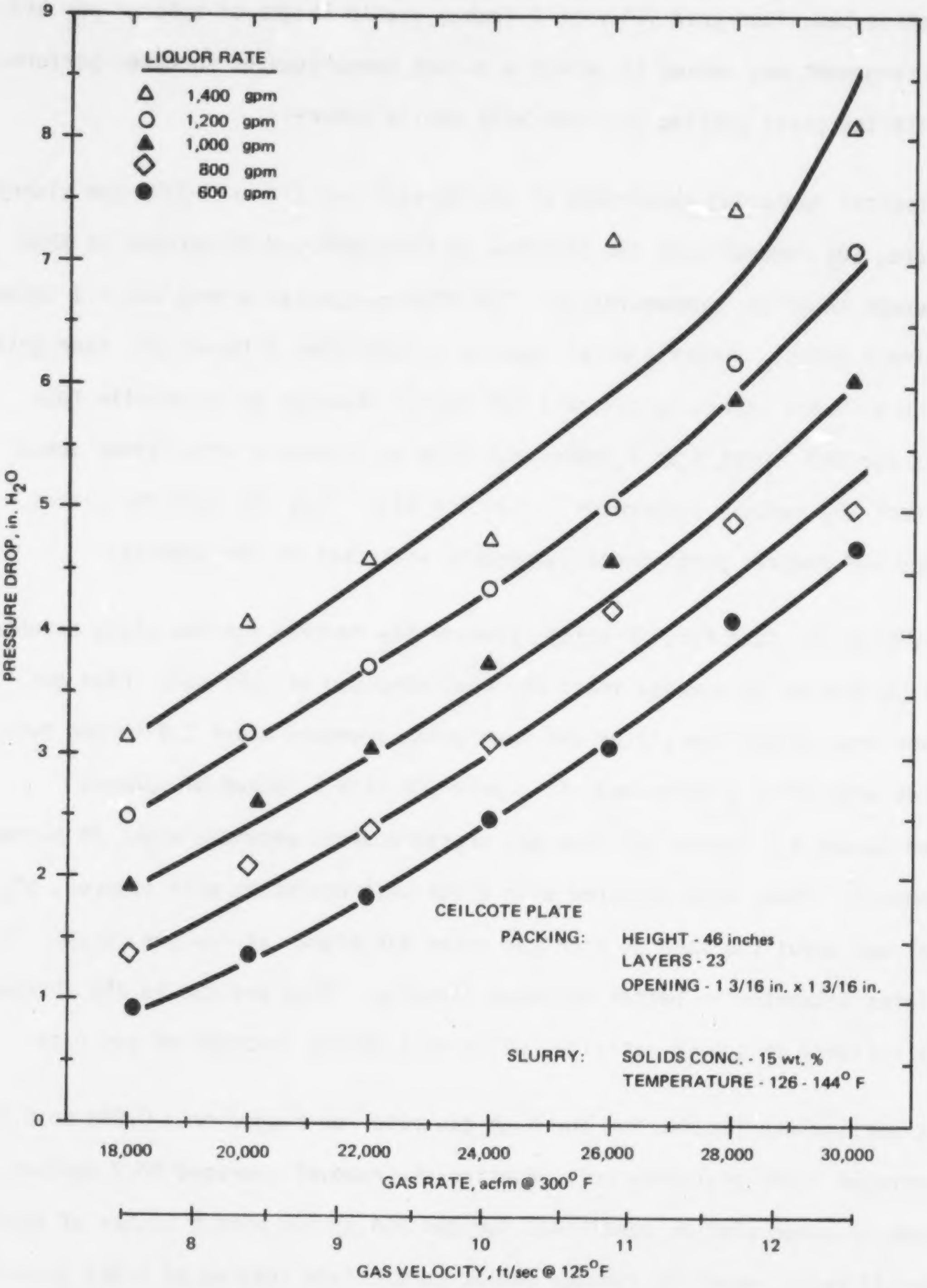

Figure 9-11. **PRESSURE DROP ACROSS 4 BAR GRIDS AND 23 LAYERS OF CEILCOTE SUPPORT PLATE PACKING**

for a three-bed, four-grid TCA with 5 inches static height of spheres per bed. This arrangement was chosen to permit a direct comparison of scrubber performance with the plate packing and that with mobile spheres.

Under typical operating conditions of 30,000 acfm gas flow and 1200 gpm slurry flow rate, SO_2 removal with the Ceilcote packing averaged 76 percent at 3200 ppm average inlet SO_2 concentration. The flue gas pressure drop was 7.2 inches H_2O (with 4 grids). Under similar operating conditions a three-bed, four-grid TCA with 5 inches static height of 1-5/8 inches diameter solid nitrile foam spheres per bed (about 8 to 9 inches H_2O flue gas pressure drop) gives about 80 percent SO_2 removal (Reference 5, Section 14). Thus the Ceilcote plates provided SO_2 removal performance comparable with that of the spheres.

At a reduced gas rate (18,000 acfm), average SO_2 removal for the plate scrubber was 86 percent at an average inlet SO_2 concentration of 3050 ppm. Flue gas pressure drop across the plates and four grids averaged about 2.9 inches H_2O. Compared with this, a three-bed, four-grid TCA with 5 inches of spheres per bed (about 4.5 inches H_2O flue gas pressure drop) provides about 78 percent SO_2 removal. Thus, when compared with a TCA unit operating with spheres, SO_2 removal was about the same at high gas rates and higher at low gas rates. Thus, the plates demonstrated better turndown capacity. This was due to the absence of any reliance on sphere activity, which is a strong function of gas rate.

Outlet particulate loading for the high gas rate run ranged from 0.038 to 0.046 and averaged 0.042 grain/dry scf. Particulate removal averaged 98.9 percent, the same as under similar conditions for the TCA system with 5 inches of spheres per bed (3 beds), where an average outlet particulate loading of 0.064 grain/dry scf was observed. Comparable performance was observed at the low gas rate.

No plugging occurred during tests with the Ceilcote packing. Minor scale formation was observed along the edges of some of the plates. However, the overall duration of the tests (326 hours total) was not sufficient to evaluate reliability.

9.1.6 Range of Operating Conditions

This subsection addresses the range of operating conditions as they are determined by general mechanical considerations. Ranges of chemical parameters such as pH, inlet SO_2 concentration, chloride concentrations, etc., are discussed in Sections 3.2 and 4.2.

The major independent variables are:

- Gas flow rate (or gas velocity)
- Packing type and height
- Slurry flow rate.

The limits of gas flow rate are determined by two primary considerations. At the low end, the gas flow rate should be adjusted to promote fluidization of the sphere bed; at the high end, the gas flow rate should be regulated to prevent flooding of the scrubber (see Section 9.1.2) and overloading of the mist eliminator (re-entrainment of slurry dripping from the mist eliminator vanes). Flooding the scrubber will result in excessive pressure drop and fan overload. Overloading the mist eliminator will result in high outlet particulate loading and additional fouling of the downstream equipment.

The range of gas flow tested on the TCA was 18,000 to 30,000 acfm @ 300°F. The corresponding gas velocity of the saturated gas (at 125°F) was 7.5 to 12.5 ft/sec.

The maximum slurry flow rate is determined primarily by the recirculating pump capacity. However, at a given gas flow rate, the major constraint on slurry flow rate is the pressure drop at which flooding occurs (see Figure 9-3 through 9-6). The range of slurry flow rates tested on the TCA was 600 to 1400 gpm. The combination of the gas and slurry flow rate ranges tested at Shawnee resulted in an L/G (liquid-to-gas) ratio range of 25 to 100 gal/mcf.

Two types of packings were tested on the TCA. Over 95 percent of the testing was done using mobile spheres of various kinds (Section 9.1.4). The only other type tested was Ceilcote egg-crate type packing (Section 9.1.5).

During testing with spheres the number of sphere beds was varied from 0 to 3, and the sphere height/bed was varied from 0 to 10 inches (Section 9.1.2). Egg-crate type packing was tested at a depth of 46 inches only.

The packing type, height, gas flow rate, and slurry flow rate interact with each other and with the scrubber geometry in a complex manner to determine the turndown characteristics. As noted earlier the Ceilcote plate packing demonstrated better turndown capacity than the mobile spheres. This is expected because the gas-slurry contact efficiency for spheres is a stronger function of gas velocity than for plate packing.

9.2 VENTURI

9.2.1 Description

The adjustable-throat venturi scrubber in the venturi/spray tower system was manufactured by Chemical Construction Company (Chemico). The venturi scrubber removes the bulk of the particulates. Because the residence time in the venturi scrubber is low, SO_2 removal with lime/limestone slurry is inadequate.

Figure 9-12 (with major dimensions to scale) is a schematic of the scrubber. Like the TCA scrubber, the venturi is capable of treating approximately 30,000 acfm of flue gas from Boiler No. 10. In this service it performs effectively over the range of inlet SO_2 and particulates encountered at Shawnee.

Provision is made for separating the venturi effluent from the spray tower effluent by incorporating a trapout device at the base of the spray tower. This is further described in Section 13.1.7. Total independent operation of either venturi or spray tower is not possible.

9.2.2 Pressure Drop

Pressure drop across the venturi scrubber is a function of the gas flow rate, the slurry flow rate, and the annulus cross-sectional area (the annular space between the venturi throat and the plug). The annulus cross-sectional area is varied by changing the vertical position of the plug. This feature has been utilized routinely at Shawnee to maintain constant pressure drop across the venturi at various combinations of gas and slurry flow rates. The range of pressure drop tested was 3 to 12 inches H_2O.

The following equation has been fitted to the venturi air/water and soda-ash pressure drop data (Reference 1, Section 12):

$$\Delta P = 2.8 \times 10^{-4} V_t^{2} + 7.5 \times 10^{-5} V_t^{2.38} (L/G)^{0.897} (1/D)^{1.68} \qquad (9\text{-}3)$$

with:

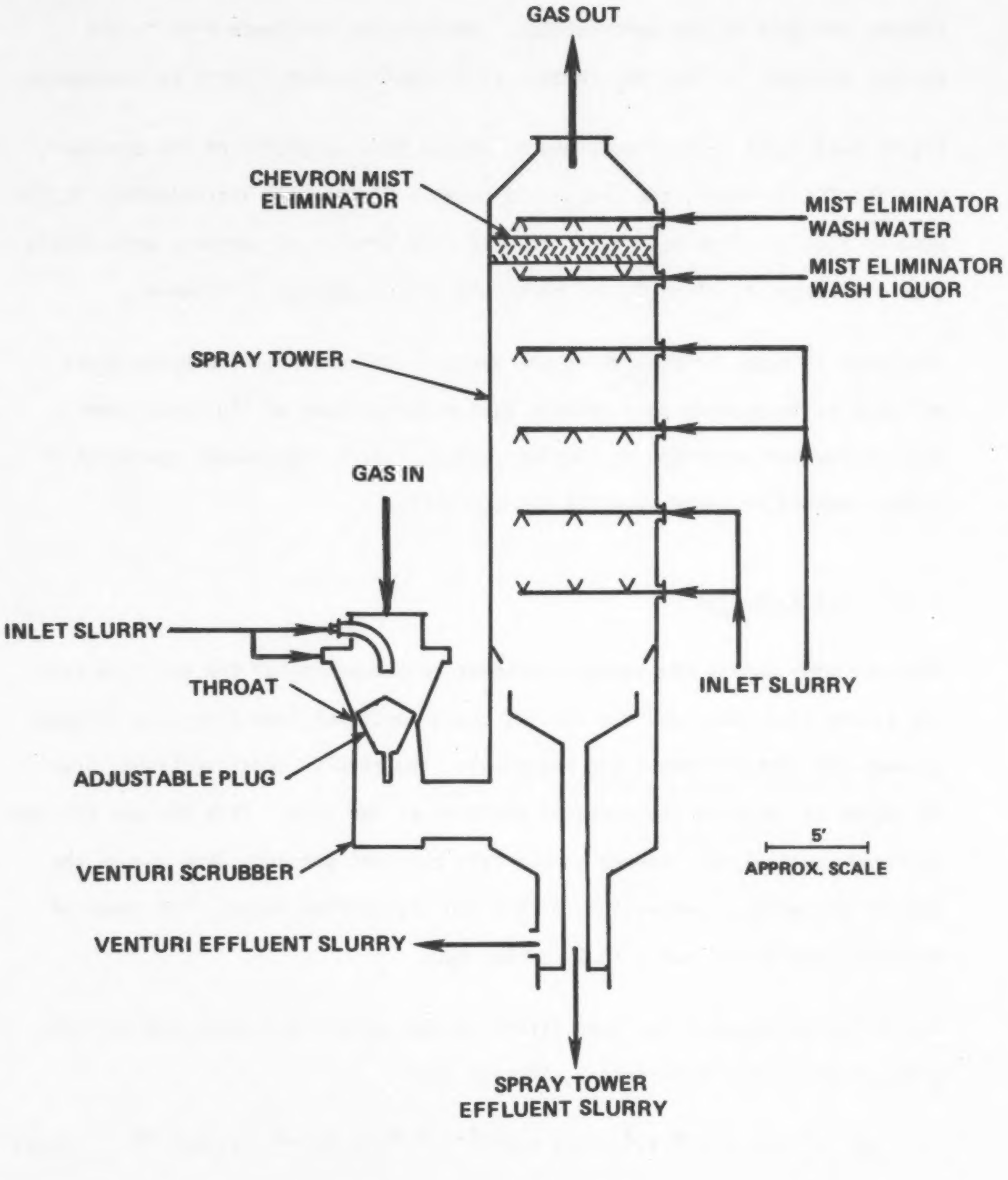
GAS OUT
CHEVRON MIST ELIMINATOR
MIST ELIMINATOR WASH WATER
MIST ELIMINATOR WASH LIQUOR
SPRAY TOWER
GAS IN
INLET SLURRY
THROAT
ADJUSTABLE PLUG
INLET SLURRY
5'
APPROX. SCALE
VENTURI SCRUBBER
VENTURI EFFLUENT SLURRY
SPRAY TOWER EFFLUENT SLURRY

FIGURE 9-12. SCHEMATIC OF VENTURI SCRUBBER AND SPRAY TOWER

$$l = 0.56 + 0.009Z$$

$$A_t = 1.8 + 0.048Z$$

where:

ΔP = pressure drop across venturi, inches H_2O

V_t = gas velocity at throat, ft/sec

L/G = liquid-to-gas ratio through scrubber, gal/mcf

l = throat length, ft

D = venturi plug diameter = 3.2 ft. for the Chemico venturi

A_t = venturi throat area (used to calculate gas velociity), ft^2

Z = percent opening of plug

The constant in the first term on the right-hand side of Equation 9-3 was fitted to the "air only" (L=0) data. The four coefficents in the second term on the right-hand side were fitted to the remaining data.

Equation 9-3 accounted for 97 percent of the variation of the air/water and soda-ash data, with a standard error of estimate of 0.7 inch H_2O. Measured and predicted (Equation 9-3) values of venturi pressure drop are compared in Figure 9-13. Also shown in Figure 9-13, but not included in the fit of Equation 9-3, is the pressure drop data for the early limestone factorial runs (Reference 1).

The four coefficients in the second term on the right-hand side of Equation 9-3 were also fitted to the earlier limestone factorial data. The resultant equation is:

$$\Delta P = 2.8 \times 10^{-4} V_t^2 + 10.0 \times 10^{-5} V_t^{2.46} (L/G)^{0.62} (l/D)^{1.36} \qquad (9\text{-}4)$$

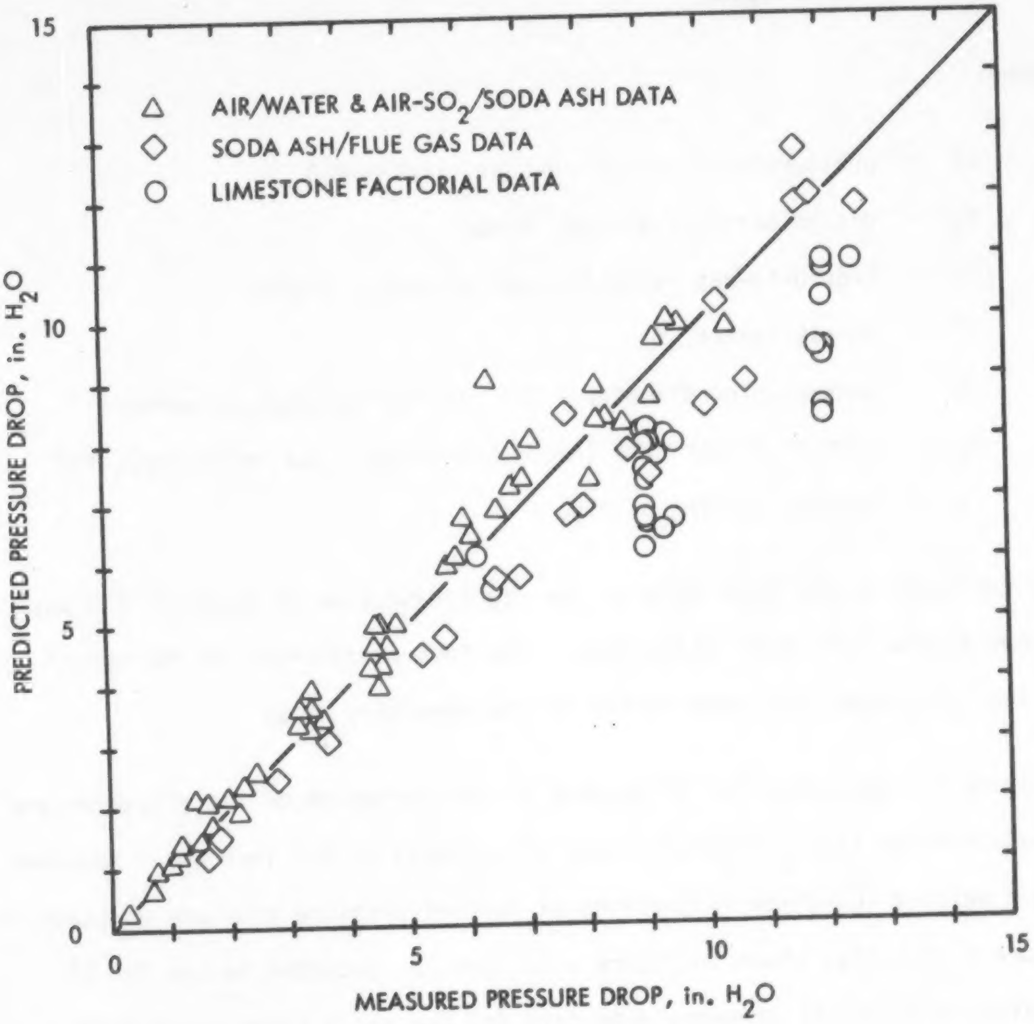

Figure 9-13. Comparison of Experimental Data and Predicted Values of Pressure Drop in the Chemico Venturi from Equation 9-3.

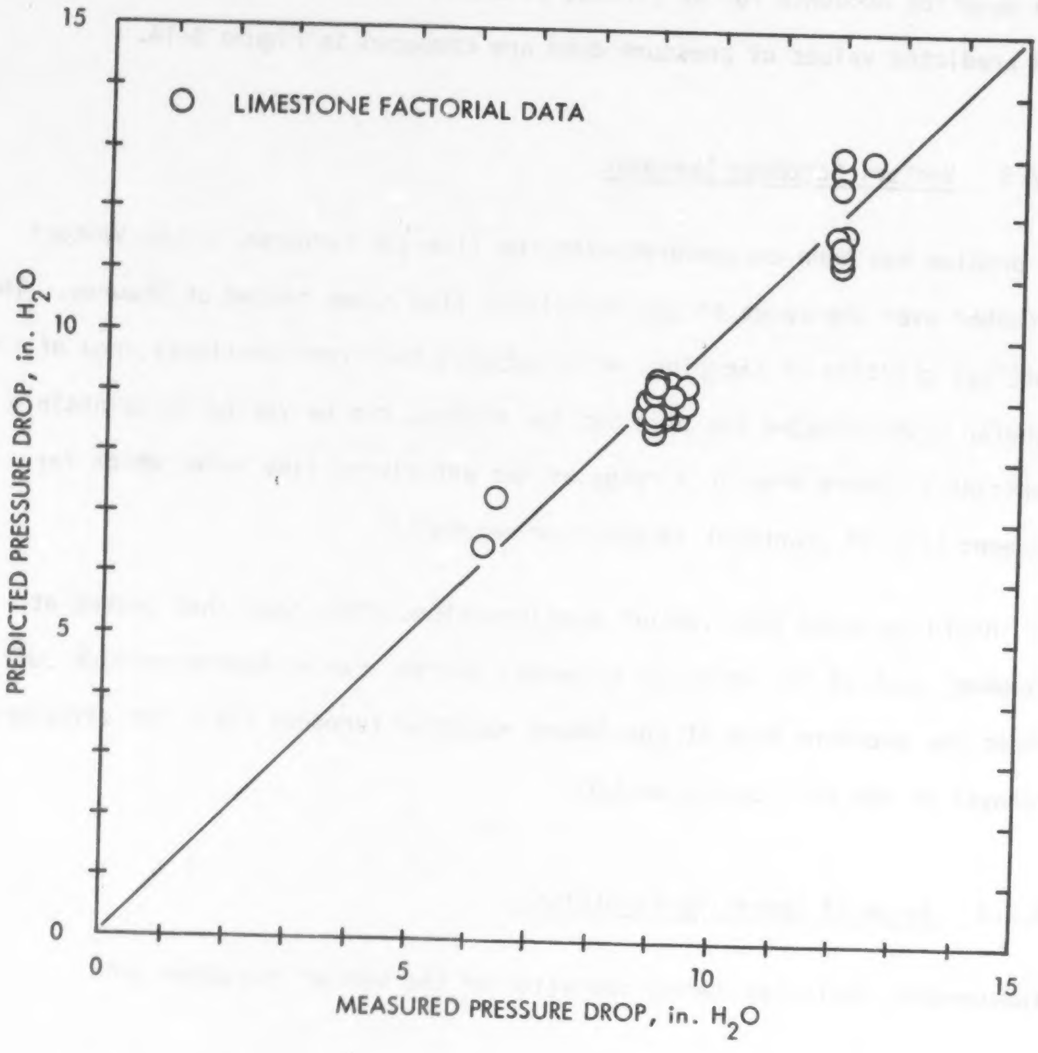

Figure 9-14. Comparison of Experimental Data and Predicted Values of Pressure Drop in the Chemico Venturi from Equation 9-4.

The equation accounts for 92 percent of the variation of the data. Measured and predicted values of pressure drop are compared in Figure 9-14.

9.2.3 Venturi Scrubber Turndown

No problem has been encountered with the flue gas turndown in the venturi scrubber over the range of gas and slurry flow rates tested at Shawnee. The vertical position of the plug, which adjusts the cross-sectional area of the annular space between the plug and the throat, can be varied to maintain a constant pressure drop at a range of gas and slurry flow rates which far exceeds that of practical interest or necessity.

It should be noted that venturi configurations other than that tested at Shawnee, such as the rectangular throat design, can of course provide sufficient gas pressure drop at the lowest expected turndown ratio for efficient removal of the particulate matter.

9.2.4 Range of Operating Conditions

Independent variables during operation of the venturi scrubber are:

- Gas flow rate
- Slurry flow rate
- Annulus cross-sectional-area

Over the years the gas flow rate has ranged from 18,000 to 35,000 acfm, and the slurry flow rate from 140* to 600 gpm. Except for minimum slurry flow conditions in which all slurry is introduced above the plug through a bull nozzle, approximately three-fourths of the slurry is introduced via the bull nozzle with the balance being fed via four tangential nozzles located along the upper periphery of the scrubber (Figure 9-12).

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* The minimum slurry flow rate is dictated by the minimum controllable flow rate on the recirculating pump used.

The annulus cross-sectional area is varied by changing the position of the adjustable plug, which varied the pressure drop. A pressure drop variation of 3 to 12 inches H_2O has been tested.

9.3 SPRAY TOWER

9.3.1 Description

The spray tower in the venturi/spray tower system was manufactured by Chemical Construction Company (Chemico). It is operated with up to 4 slurry headers. The top three headers, with 7 nozzles each, spray downward (countercurrent to gas flow) whereas the bottom header, with 7 nozzles, usually sprays upward. In the earlier test program during the mist eliminator reliability testing, the bottom header sprayed downward to minimize the slurry entrainment. The distance between the headers is about 4 ft. The empty cross-sectional area of the spray tower in the scrubbing and mist eliminator sections is 50 ft^2.

Figure 9-12 (drawn with major dimensions to scale) is a schematic of the scrubber. The chevron mist eliminator used during the entire testing period is shown in Figure 9-2. The scrubber performed effectively over the range of flue gas flow rates and compositions encountered at Shawnee.

Provision is made for separating the venturi effluent from the spray tower effluent by incorporating a trapout funnel at the base of the spray tower. This is further described in Section 13.1.7. Tests have been made both with and without the trapout funnel. Because of the physical layout of the flue gas ductwork, independent operation of either venturi or spray tower is not possible.

9.3.2 Pressure Drop

Flue gas pressure drop across the four slurry headers in the spray tower was measured in March, 1978, as a function of superficial gas velocity, total slurry flow rate, and number and position of the headers in use. The lower pressure tap was located 20 inches below the center-line of the bottom header and the upper tap 7 inches above the center-line of the top header.

Figure 9-15 shows flue gas pressure drop as a function of superficial gas velocity and slurry flow rate with all four spray headers in use. Figure 9-16 presents the effect of the number and position of spray headers on the flue gas pressure drop at 14 gpm/ft^2 total slurry flow rate.

Equation 9-5 is a correlation of flue gas pressure drop as a function of gas and slurry flow rates for the case when all four slurry headers were used (see Figure 9-15):

$$\Delta P = 0.0062 v^{1.17} \exp(0.084L) \tag{9-5}$$

where:

ΔP = flue gas pressure drop across four spray headers, inches H_2O.

v = superficial gas velocity in the spray tower, ft/sec at 125°F

L = slurry flow rate to four headers, gpm/ft^2 of spray tower cross-sectional area (Shawnee spray tower cross-sectional area = 50 ft^2)

Equation 9-5 accounts for 92 percent variation in the data with a standard error estimate of 0.06 inch H_2O.

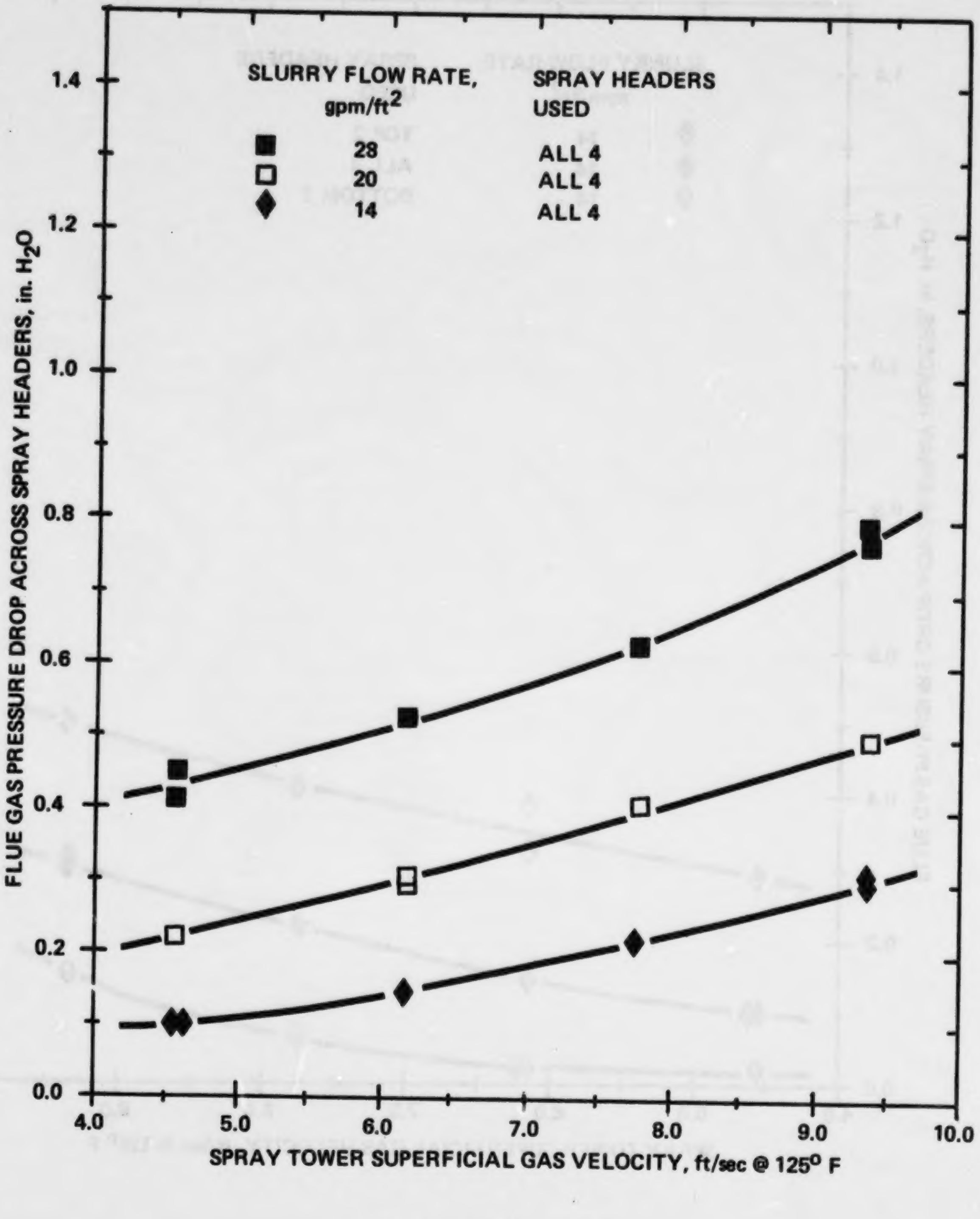

Figure 9-15

THE EFFECT OF GAS VELOCITY AND SLURRY FLOW RATE ON THE FLUE GAS PRESSURE DROP ACROSS THE FOUR SLURRY HEADERS IN THE SPRAY TOWER

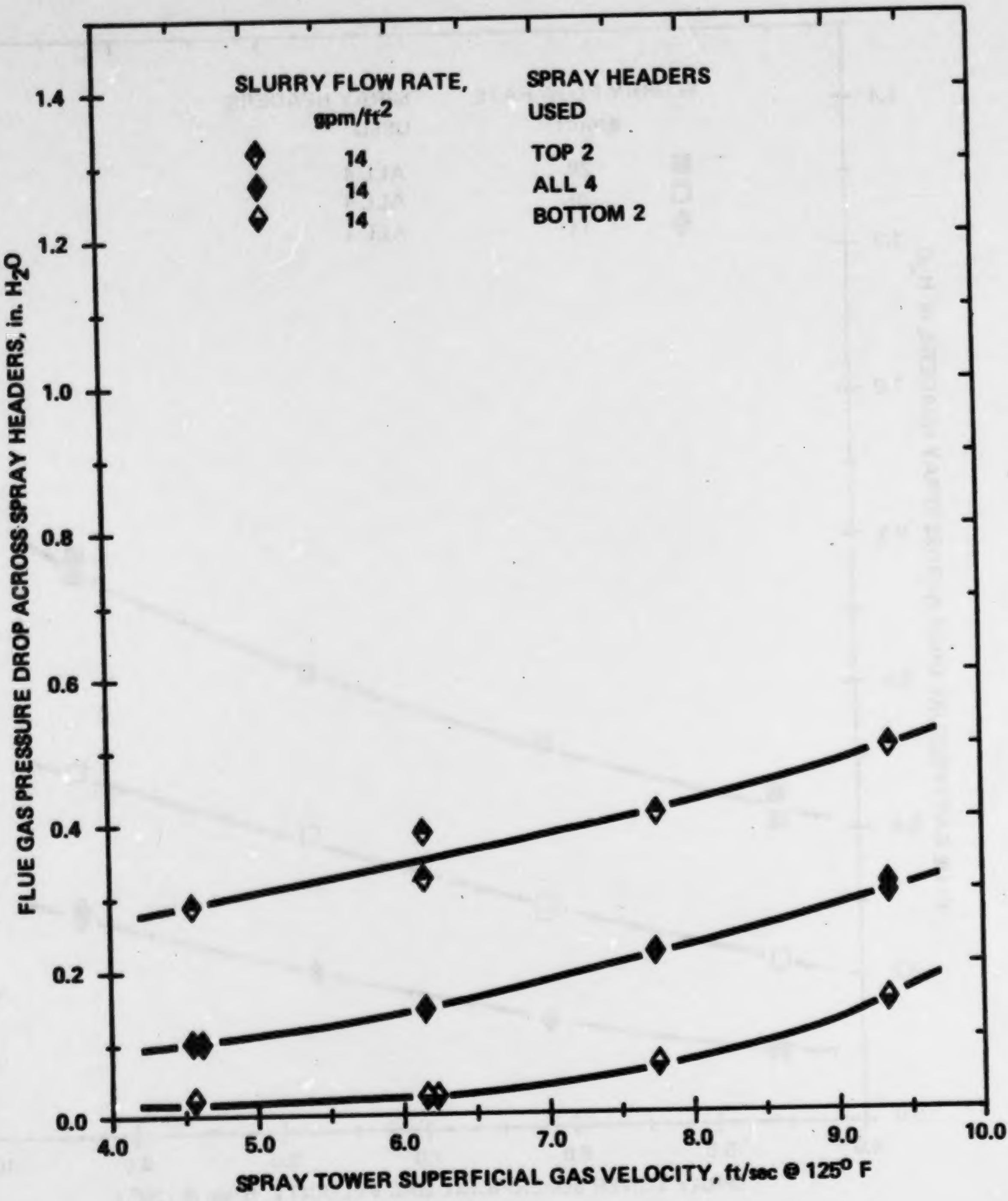

Figure 9-16

THE EFFECT OF HEADER POSITION AND NUMBER OF HEADERS ON THE FLUE GAS PRESSURE DROP AT 14 gpm/ft^2 TOTAL SLURRY FLOW RATE

The effects of header position and the number of headers on the pressure drop were studied at 14 gpm/ft^2 total slurry flow rate. Figure 9-16 indicates that pressure drop was the highest when only the top two headers were used, next highest with all four headers, and lowest with only the bottom two headers. This could be explained by the fact that the slurry holdup in the spray tower between the pressure taps is likely to be the highest when the top two headers are used, and lowest when the bottom two headers are used.

9.3.3 Spray Tower Turndown

In addition to the advantage of open internal design, which minimizes the scaling and plugging potential in slurry service, the spray tower has turndown over an infinite range. The spray tower is also capable of operating at higher-than-design gas velocity without flooding, subject to the limitations of mist eliminator overloading and fan capacity. The minimum gas flow rate of 18,000 acfm (4.8 ft/sec) at Shawnee was determined by the tightness of the fan damper closure. Low gas flow rate should give better gas flow distribution. This would undoubtedly be true as well in a large scale unit.

9.3.4 Range of Operating Conditions

Important operating parameters for the spray tower are:

- Gas flow rate
- Slurry flow rate
- Number of slurry spray headers
- Header combinations

Unlike a TCA, the effect of gas flow rate (or liquid-to-gas ratio at constant slurry flow rate) on the performance of the spray tower is quite significant

(Figures 7-5 and 7-9). The level of gas flow affects the residence time of the liquid droplets in the scrubber (via hold up), the residence time of the gas in the scrubber, and the intensity of impact between the liquid droplets and the gas molecules. At high gas flow rates the negative effect of the lower gas residence time in the scrubber is offset by the increased intensity of contact and higher liquid holdup. At Shawnee, gas flow ranged from 18,000 to 35,000 acfm (@ 300°F). The corresponding velocity of the saturated gas (at 125°F) was 4.8 to 9.4 ft/sec.

Generally in spray tower systems, absorption occurs primarily in the vicinity of the spray nozzles before significant coalescence of slurry droplets takes place. The effective absorption zone may have a radius as low as 12 inches, depending on the droplet size. For this reason spray towers are designed with multiple headers containing several high efficiency, atomizing nozzles (see Section 9.3).

At Shawnee the spray tower was operated with one to four headers. The slurry flow per header ranged from 0 to 400 gpm. Combination of the gas and slurry flow rate ranges resulted in an L/G (liquid-to-gas) ratio range of 15 to 110 gal/mcf. During testing all possible header combinations were evaluated. Combinations using the upper headers (higher liquid holdup and residence time) and higher flow per nozzle (better atomization) provided better SO_2 removal efficiency.

It should be noted that the Shawnee spray tower design is not optimized. Optimization of the spray tower internal design has been planned in the future program.

Section 10

WATER BALANCES AROUND SCRUBBER SYSTEMS

The water balances around scrubber systems have been calculated in order to determine the quantity of raw (makeup) water that can be used for the fresh alkali slurry preparation, mist eliminator wash, and the process pump seals in a closed-liquor-loop operation. Data from typical Shawnee lime and limestone runs was used to calculate the makeup water requirements and to investigate those factors which have an effect on the water balance.

10.1 FACTORS AFFECTING WATER BALANCES

The most significant factor affecting the water balance for closed-loop Shawnee systems was water loss through evaporation (flue gas humidification). The scrubber operating parameters which affected evaporation were gas rate and temperature. For typical Shawnee operation at hot gas temperature of 300°F, gas rates between 30,000 and 35,000 acfm (at 300°F), and scrubber temperatures (wet bulb temperatures) between 125°F and 130°F, approximately 9 gpm is lost through evaporation, including an estimated 0.2 gpm entrainment.

Water losses with the discharged scrubber waste solids account for the remainder of the makeup water requirements. These losses take two forms:

- Free water discharged with the solids
- Water of hydration as $CaSO_3 \cdot 1/2H_2O$ and $CaSO_4 \cdot 2H_2O$

The waste solids discharge rate is a function of the rates of fly ash and SO_2 removed and excess alkali added. The quantity of free water lost depends upon the weight percent of solids in the waste sludge discharged. It is greater for a limestone than for a lime system because the higher alkali stoichiometries for limestone result in a higher solids discharge rate. At Shawnee free water loss ranged from 0.7 to 7 gpm.

The water of hydration losses are dependent upon the degree of sulfite oxidation. Because two molecules of water combine with calcium sulfate while only half a molecule of water combines with calcium sulfite, more hydration water is lost during forced oxidation operation. These losses range from 0.2 gpm without forced oxidation to 0.6 gpm with forced oxidation.

Tables 10-1 through 10-3 give eight examples of water balances calculated from Shawnee operation at flue gas flow rates of 30,000-35,000 acfm at 300°F (equivalent to 10 megawatts). A material balance computer program, which is a part of the Design/Economics Computer Program being developed jointly by TVA and Bechtel, was used to calculate the water balances (Reference 16). The SO_2 inlet concentrations averaged 2550 ppm. Chloride content in coal was assumed to be 0.05 weight percent. Makeup water requirements were calculated for four limestone and four lime cases. The following conditions applied to each alkali:

1. Forced oxidation with two-stage dewatering (clarifier followed by either filter or centrifuge) and high fly ash.
2. No oxidation with two-stage dewatering and high fly ash.

Table 10-1

SUMMARY OF WATER BALANCES FOR LIMESTONE RUNS

Test Conditions	Forced Oxidation Clarifier & Filter or Centrifuge	No Oxidation Clarifier & Filter or Centrifuge	No Oxidation Clarifier Only
Flue Gas Rate, Macfm @ 300°F (1)	30-35	30-35	30-35
Fly Ash Loading, gr/wet scf	4.7	4.7	4.7
Percent solids Recirculated	15	15	15
Percent Solids in Discharged Sludge	80	60	40
SO_2 Removal, Percent	85	85	85
Limestone Stoichiometric Ratio, moles Ca^{++} added/mole SO_2 absorbed	1.4	1.4	1.4
Percent Sulfite Oxidized	95	30	30
Scrubber Inlet pH	5.5	5.5	5.5
Water Output, gpm			
Evaporation (2)	9	9	9
Hydrated Water in Discharged Solids	0.5	0.3	0.2
Water in discharge stream	1.3	3.1	7.1
Total	10.8	12.4	16.3
Water Input, gpm			
Water in Limestone Slurry (60% limestone)	1.5	1.5	1.5
Mist Eliminator Wash	7.8	9.4	14.8
Pump seal water (3)	1.5	1.5	0
Total	10.8	12.4	16.3
Dissolved Concentrations of Liquor Species, ppm			
Scrubber System discharge pH	7.60	7.60	7.60
Ca^{++}	1225	1050	920
Mg^{++}	3175	1295	575
$SO_3^{=}$	320	230	185
$SO_4^{=}$	6095	3685	2620
Cl^{-}	6635	2705	1200

(1) 30% excess air included
(2) including 0.2 gpm entrainment
(3) clarifier underflow pump

Table 10-2

SUMMARY OF WATER BALANCES FOR LIME RUNS

Test Conditions	Forced Oxidation Clarifier & Filter or Centrifuge	No Oxidation Clarifier & Filter or Centrifuge	No Oxidation Clarifier Only
Flue Gas Rate, Macfm @ 300°F (1)	30-35	30-35	30-35
Fly Ash Loading, gr/wet scf	4.7	4.7	4.7
Percent solids Recirculated	8	8	8
Percent Solids in Discharged Sludge	80	60	40
SO_2 Removal, Percent	90	90	90
Lime Stoichiometric Ratio, mole Ca^{++} added/mole SO_2 absorbed	1.05	1.05	1.05
Percent Sulfite Oxidized	95	30	30
Scrubber Inlet pH	7.0	7.0	7.0
Water Output, gpm			
Evaporation (2)	9	9	9
Hydrated Water in Discharged Solids	0.6	0.3	0.3
Water in Discharge Stream	1.2	2.8	6.4
Total	10.8	12.1	15.7
Water Input, gpm			
Water to Lime Slaker (20% lime)	5.3	5.3	5.3
Mist Eliminator Wash	4.0	5.3	10.4
Pump Seal Water (3)	1.5	1.5	0
Total	10.8	12.1	15.7
Dissolved Concentrations of Liquor Species, ppm			
Scrubber System discharge pH	7.40	7.45	7.55
Ca^{++}	2710	1600	1130
Mg^{++}	1380	570	255
$SO_3^=$	165	160	155
$SO_4^=$	2030	1865	1735
Cl^-	7175	2970	1315

(1) 30% excess air included
(2) including 0.2 gpm entrainment
(3) clarifier underflow pump

Table 10-3

WATER BALANCES FOR RUNS WITH HIGH AND LOW FLY ASH LOADING WITH FORCED OXIDATION AND TWO-STAGE DEWATERING

Test Conditions	Limestone High Fly Ash	Limestone Low Fly Ash	Lime High Fly Ash	Lime Low Fly Ash
Flue Gas Rate, Macfm @ 300°F (1)	30-35	30-35	30-35	30-35
Fly Ash Loading, gr/wet scf	4.7	0.2	4.7	0.2
Percent solids Recirculated	15	8	8	4
Percent Solids in Discharged Sludge	80	80	80	80
SO_2 Removal, Percent	85	85	90	90
Alkali Stoichiometric Ratio, moles Ca^{++} added/mole SO_2 absorbed	1.4	1.4	1.05	1.05
Percent Sulfite Oxidized	95	95	95	95
Scrubber Inlet pH	5.5	5.5	7.0	7.0
Water Output, gpm				
Evaporation (2)	9	9	9	9
Hydrated Water in Discharged Solids	0.5	0.5	0.6	0.6
Water in Discharge Stream	1.3	0.8	1.2	0.7
Total	10.8	10.3	10.8	10.3
Water Input, gpm				
Alkali Makeup Water	1.5	1.5	5.3	5.3
Mist Eliminator Wash	7.8	7.3	4.0	3.5
Pump Seal Water (3)	1.5	1.5	1.5	1.5
Total	10.8	10.3	10.8	10.3
Dissolved Concentrations of Liquor Species, ppm				
Scrubber System Discharge pH	7.60	7.60	7.40	7.30
Ca^{++}	1225	1315	2710	3785
Mg^{++}	3175	4820	1380	2190
$SO_3^{=}$	320	405	165	170
$SO_4^{=}$	6095	8050	2030	2105
Cl^{-}	6635	10,075	7175	11,375

(1) 30% excess air included
(2) including 0.2 gpm entrainment
(3) clarifier underflow pump

3. No oxidation with clarifier only and high fly ash.
4. Forced oxidation with two-stage dewatering and low fly ash.

These cases are reviewed in Sections 10.2 through 10.5.

10.2 LIMESTONE SYSTEMS WITH HIGH FLY ASH LOADING

Water balances for typical limestone runs with high fly ash are presented in Table 10-1. SO_2 removal for these runs averaged 85 percent with a limestone stoichiometry of 1.4 moles Ca^{++} added/mole SO_2 absorbed. Fly ash loading averaged 4.7 grains/wet scf (based on inlet gas containing about 8 percent moisture), and the recirculated slurry solids were controlled at 15 weight percent. With forced oxidation 95 percent of the sulfite was converted to sulfate, whereas only 30 percent was oxidized without forced oxidation. Discharged solids content averaged 80 weight percent with forced oxidation and two-stage dewatering. Without forced oxidation, discharged solids content averaged 60 weight percent with two-stage dewatering and 40 weight percent using the clarifier only.

10.2.1 Water Balances

Only 10.8 gpm makeup water was required for operation using two-stage dewatering and forced oxidation. Evaporation* accounted for 9 gpm of the losses. Another 1.8 gpm left the system with the discharged solids, 1.3 gpm of that as free water and the remaining 0.5 gpm as hydration water. Raw (makeup) water was supplied to the system at a rate of 1.5 gpm in the limestone slurry,

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* In all cases discussed in this section evaporation includes about 0.2 gpm entrainment.

1.5 gpm in the clarifier underflow pump seal water, with the remaining 7.8 gpm available for the mist eliminator wash.

Closed-loop scrubber operation without forced oxidation with two-stage dewatering required 12.4 gpm of makeup water. Again, 9 gpm was lost to evaporation. Free water in the discharge stream amounted to 3.1 gpm, and 0.3 gpm left the system as hydrated solids. The limestone feed system supplied 1.5 gpm of the raw water, the clarifier underflow pump supplied another 1.5 gpm as pump seal water, and the mist eliminator wash supplied the remaining 9.4 gpm required.

Without forced oxidation, using only the clarifier for dewatering, a total of 16.3 gpm left the system. This consisted of 9 gpm through evaporation, 7.1 gpm as free water with the discharged sludge, and 0.2 gpm with the hydrated solids. Raw water was supplied at a rate of 1.5 gpm with the limestone feed and 14.8 gpm with the mist eliminator wash. Since the system used only one dewatering stage (clarifier only), seal water for the clarifier underflow pump did not contribute to the system water balance.

10.2.2 Dissolved Solids Concentrations

Except for sulfate concentration which varied with magnesium concentration, concentrations of dissolved species in the liquor in equilibrium with slurry solids, such as calcium and sulfite, were only slightly affected by loop tightness (percent solids in discharged sludge). Calcium and sulfite concentrations decreased from 1225 ppm to 920 ppm and 320 ppm to 185 ppm, respectively, for the tightest loop versus most open cases explored. However, highly soluble species not in equilibrium with slurry solids, notably chlorides, decreased in concentration from 6635 ppm to 1200 ppm as loop tightness decreased.

10.3 LIME SYSTEMS WITH HIGH FLY ASH LOADING

Table 10-2 presents the water balances for typical lime runs with high fly ash loading. SO_2 removals averaged 90 percent at a lime stoichiometric ratio of 1.05 moles Ca^{++} added/mole SO_2 absorbed. Fly ash loading averaged 4.7 grains/wet scf (based on inlet gas containing about 8 percent moisture), and the recirculated slurry solids were controlled at 8 weight percent. The discharged solids averaged 80, 60, and 40 weight percent for forced oxidation with two-stage dewatering, no forced oxidation with two-stage dewatering, and no forced oxidation using only the clarifier, respectively.

10.3.1 Water Balances

Makeup water requirements for operation with forced oxidation and two-stage dewatering amounted to 10.8 gpm. Evaporation accounted for 9 gpm of the losses, with another 1.2 gpm leaving the system as free water and 0.6 gpm in hydrated solids. Entering the system was 5.3 gpm with the slaked lime and 1.5 gpm through the clarifier underflow pump seals. This left the remaining 4.0 gpm available for the mist eliminator wash.

When oxidation was not forced, using two-stage dewatering, 12.1 gpm left the system. Evaporation losses were again 9 gpm. Free water leaving the system amounted to 2.8 gpm, and hydrated water leaving with the discharged solids amounted to an additional 0.3 gpm. These losses were offset by 5.3 gpm entering with the slaked lime, 1.5 gpm with the clarifier underflow pump seals, leaving the remaining 5.3 gpm with the mist eliminator wash.

When only the clarifier was used for dewatering and oxidation was not forced, 15.7 gpm was needed to equalize the losses. Evaporation losses accounted for 9 gpm, free water left the system with the discharged solids at a rate of 6.4 gpm, and 0.3 gpm was lost with the hydrated solids. The lime slaker added 5.3 gpm to the system. The mist eliminator wash provided the remaining 10.4 gpm.

10.3.2 Dissolved Solids Concentrations

As with the limestone system, the concentrations of dissolved species in equilibrium with slurry solids were relatively unaffected by loop closure. Calcium concentration decreased from 2710 ppm to 1130 ppm, and sulfite decreased from 165 ppm to 155 ppm as the liquor loop became more open. Sulfate concentration varied only slightly, from 2030 ppm to 1735 ppm, and was lower than the limestone case because of the lower magnesium concentration. Similar to the limestone cases, chlorides decreased in concentration from 7175 ppm to 1315 ppm with decreasing loop tightness. The discharge slurry pH increased from 7.40 to 7.55 as the chloride concentration decreased.

10.4 LIMESTONE AND LIME SYSTEMS WITH LOW FLY ASH LOADING

The previous water balances for limestone and lime systems with high fly ash were compared with similar systems where 96 percent of the fly ash was removed upstream of the scrubber (Table 10-3). One limestone and one lime case with low fly ash loading were studied under conditions of forced oxidation with two-stage dewatering. Conditions were the same as for high fly ash, except that the recirculated slurry solids concentrations were adjusted to compensate for significantly less inert (fly ash) material. For the limestone case 8 weight percent solids were in the recirculated slurry. Four weight percent solids were in the recirculated slurry for the lime case.

10.4.1 Water Balances

The makeup water requirements for the limestone run with low fly ash, shown in Table 10-3, totaled 10.3 gpm. Evaporation accounted for 9 gpm of the water leaving the system. An additional 1.3 gpm left the system, including 0.8 gpm in the discharge stream as free water and 0.5 gpm as hydration water with the solids. This was balanced by adding 1.5 gpm to the system with the limestone slurry, 1.5 gpm with the clarifier underflow pump seal water, leaving the remaining 7.3 gpm to enter as the mist eliminator wash.

For the low fly ash lime system studied, the total makeup water requirement was 10.3 gpm. Again, 9 gpm left the system through evaporation. Free water left the system at a rate of 0.7 gpm and hydrated water at a rate of 0.6 gpm. Water entered the system at a rate of 5.3 gpm with the lime feed, 1.5 gpm through the clarifier underflow pump seal, leaving 3.5 gpm for the mist eliminator wash sprays.

10.4.2 Dissolved Solids Concentrations

Dissolved species in equilibrium with slurry solids (calcium, sulfite, and sulfate) were only slightly affected by the lack of inert solids in the scrubber slurry. However, chloride concentration in the scrubber liquor increased dramatically when the systems were run with low fly ash loading. For the limestone case chlorides increased from 6635 ppm to 10,075 ppm when the fly ash was removed prior to the scrubber. When lime was used, the chlorides rose from 7175 ppm to 11,375 ppm when switching from high to low fly ash loading.

10.5 SUMMARY

Scrubber system water balances were calculated for eight cases selected in the detailed study, six with high fly ash loading, and two with 96 percent of the fly ash removed prior to the flue gas entering the scrubber. Of the eight cases studied, four were for limestone and four for lime.

Makeup water requirements are most strongly affected by evaporation to flue gas, which accounted for 9 gpm for a 10 MW-equivalent system in all eight cases studied. Free water leaving the system with the discharged solids varied by a factor of ten, from 0.7 to 7 gpm depending on loop tightness and fly ash loading. Hydrated water left with the discharged solids at a low rate of 0.2 gpm without forced oxidation and at a high rate of 0.6 gpm when oxidation was forced.

The concentration of dissolved species, in equilibrium with slurry solids, namely calcium, sulfite, and sulfate, varied only slightly with loop tightness. Highly soluble species such as chlorides were greatly affected by loop tightness and fly ash loading. Chloride concentrations in the scrubber liquor ranged from a high of 11,375 ppm for the tightest loop configuration (low fly ash, 80 weight percent solids in discharged sludge) to a low of 1200 ppm for the least tight configuration (high fly ash, 40 weight percent solids in discharged sludge).

Section 11

MIST ELIMINATOR SYSTEMS

The mist eliminator serves the function of separating entrained slurry from the flue gas leaving the scrubber. Thus, it minimizes the particulate emission from the scrubber and also protects the downstream equipment, such as the flue gas reheater and induced-draft fan, from fouling by scale and soft solids deposits.

Scrubber operating conditions, mist eliminator configuration and placement, and flushing sequences for washing solids off the mist eliminator surfaces are all important parameters in achieving trouble-free mist eliminator operation. Although it was not possible to examine every conceivable case at Shawnee, extensive effort was spent from March 1972 through early 1976 to achieve reliable mist eliminator operation (References 1, 2, and 3).

Much of the early effort was devoted to identifying and learning how to control two separate and distinct operating reliability problems. These were scaling and soft, mud-type solids deposition on the scrubber walls and internals, and especially in the relatively restricted areas of the mist eliminators. Much of the early work was also conducted at a reduced gas velocity using various combinations of mist eliminator washing techniques and hardware configurations, including a wash tray upstream of the mist eliminator to intercept the entrained slurry. In fact, it was not recognized early in the program that scaling and mud-type solids deposition were indeed separate problems, each with separate and distinct solutions. This fact was not really apparent until methods were found to adequately control both.

In a lime or limestone based system, the most frequently encountered scaling problem is due to gypsum crystals which precipitate on the scrubber internals rather than outside the scrubber in the reaction tank. Proper selection of operating parameters (such as liquid-to-gas ratio, reaction tank residence time, pH, and percent solids in the recirculated slurry) to maintain a gypsum saturation level in the scrubber below about 135 percent will prevent this type of scaling (Sections 3 and 4). The use of infrequent (once every 4 to 8 hours) top sequential washing with fresh makeup water and low pressure drop nozzles proved adequate at Shawnee for control of scaling in the mist eliminator.

Identification of operating parameters, safe operating ranges, and mist eliminator washing techniques proved more difficult and time consuming for the control of mud-type solids deposition which was superimposed over the scaling problem. The use of a wash tray upstream of the mist eliminator to transfer the mud-type deposits from the mist eliminator to an area where they could more easily be removed by washing was only marginally successful and required reduced gas flow rates. Washing techniques for the mist eliminator were ultimately found without requiring a wash tray and at scrubber design gas velocities, which limited restriction from these mud-type solids to less than 10 percent of the mist eliminator open area. These solid deposits did not hinder the scrubber operation or cause shutdown for periodic cleaning. However, the real key to successful control of these mud-type solid deposits was not found until well into the Advanced Test Program.

During tests from October 1975 through mid-February 1976 to study methods for improving limestone utilization (Reference 3), a strong correlation was found between alkali utilization and the accumulation of the mud-type solids. Above about 85 percent alkali utilization, the soft solids can easily be removed even with very infrequent (once every 4 to 8 hours) washing with fresh makeup water. In fact, an entirely clean system was maintained over an extended period using only approximately one-fourth of the available fresh makeup water (see Section 10 for available makeup water for mist eliminator wash). This important discovery was further confirmed at Shawnee in subsequent tests with high alkali utilization and was also confirmed on a different system at the TVA 1-MW Colbert pilot plant.

11.1 DESCRIPTION OF SHAWNEE MIST ELIMINATORS

The original mist eliminator used in the spray tower at the start of testing in March 1972 was a three-pass, open-vane, chevron type made of eight-gage, Type 316L stainless steel. Figure 9-2 shows the blade configuration and dimensions for this mist eliminator. With the exception of a few short tests with other types, this original design has been retained in the spray tower during the entire test program.

Figure 9-12 is a schematic of the spray tower. As shown, the mist eliminator is oriented for vertical gas flow. Provision is made for flushing both the top side and the bottom side with makeup water and/or clear liquor. The spray tower is circular in cross-section, with a 50 ft^2 cross-sectional area in both the scrubber and mist eliminator sections.

Since July 1975 the TCA has employed the same mist eliminator design as the spray tower. In the TCA, as shown in Figure 9-1, the mist elimimator is located about 7 feet above the slurry spray header. The TCA is square with a 32 ft^2 cross-sectional area in the scrubber section which expands to 49 ft^2 in the mist eliminator section. As with the spray tower, spray headers are provided for washing both the top side and bottom side of the TCA mist eliminator.

11.2 OTHER MIST ELIMINATOR CONFIGURATIONS TESTED AT SHAWNEE

Other types of mist eliminators tested at Shawnee are described below. Experiences with these systems were not favorable. These types of mist eliminators were tested before it was found that, as mentioned previously, alkali utilization has a strong effect on clean mist eliminator operation. Therefore, it is not implied that these systems are not workable because of the unfavorable experiences at Shawnee. Performances of these units could have been far better if the tests had been made at high alkali utilization.

11.2.1 Mist Eliminator with Wash Tray

The original TCA mist eliminator was a six-pass, closed-vane, stainless steel, chevron mist eliminator. A Koch wash tray was later installed in November 1972 between the mist eliminator and the slurry spray nozzles to reduce the amount of slurry solids reaching the mist eliminator. The most successful washing configuration used for this system was washing the underside of the mist eliminator continuously with a 60/40 mixture of makeup water and clarified liquor at 15 to 25 gpm (0.3 to 0.5 gpm/ft^2), and feeding the wash tray with the mist eliminator wash (which drained down onto the wash tray) plus 9 to 22 gpm of clarified liquor; the underside of the wash tray was continuously washed with the wash tray effluent liquor. Initially, intermittent steam sparging was used to clean the underside of the wash tray, but was not successful.

This mist eliminator/wash tray system was tested in limestone service from November 1972 through April 1975. The system operated reliably at 8.6 ft/sec scrubber superficial gas velocity (5.6 ft/sec at the mist eliminator) and 15 percent slurry solids concentration. There were 1835 hours of operation with only incidental soft solids deposits on the mist eliminator. However, at 10 to 12 ft/sec scrubber superfical gas velocity, the mist eliminator restriction by soft solids stabilized at 10 to 15 percent but scale and solids continued to buildup on the underside of the wash tray.

11.2.2 Two Mist Eliminators in Series

A system consisting of two identical three-pass, closed-vane, fiberglass-reinforced plastic (FRP) mist eliminators in series, purchased from UOP, was tested for five weeks in June-July 1975 in the TCA at 12.5 ft/sec scrubber superficial gas velocity. Despite a variety of washing techniques, the bottom mist eliminator could not be kept completely clean. With continuous bottom wash using diluted clarified liquor and intermittent top wash using makeup water for the lower mist eliminator (no wash for the upper mist eliminator), solids accumulation stabilized at 10 to 15 percent restriction of the lower unit and less than 5 percent restriction of the upper unit.

11.2.3 Cone-Shaped Mist Eliminator

A cone-shaped, four-pass, closed-vane, 316 stainless steel, chevron mist eliminator, fabricated by TVA, was unsuccessfully tested for about 3 months (November 1974 through January 1975) in the spray tower. The sloped-vane design of this mist eliminator supposedly should have given better drainage of slurry and wash liquor. However, a continuous wash on the under side at 0.7 gpm/ft^2 did not keep the mist eliminator completely clean.

11.2.4 Mesh Pad on Top of Mist Eliminator

A York Demister 316 stainless steel mesh pad was placed above the three-pass, open-vane, mist eliminator in the spray tower to determine if the mesh pad had an effect on the outlet particulate mass loading during a special particulate emission test series in November 1976. After 3 days of operation the pad was 30 percent restricted with entrained solids, and testing with the mesh pad was terminated. The mesh pad was not washed during the test. No significant difference was observed in outlet mass loading and mass removal efficiency with or without the York demister under the same operating conditions.

11.3 FACTORS INFLUENCING CLEAN MIST ELIMINATOR OPERATION

A wide range of operating conditions were explored in the Advanced Test Program while using the three-pass, open-vane, chevron mist eliminator in both the TCA and the spray tower. This section discusses the parameters tested and their effect on mist eliminator operation.

11.3.1 Alkali Utilization

One of the most significant findings in the Advanced Test Program was that alkali utilization (moles of SO_2 absorbed/mole of alkali feed) has a strong influence on clean mist eliminator operation. At high alkali utilization above about 85 percent, it is much easier to keep the mist eliminator clean than at lower utilization. Residual alkali in the stationary slurry solids, once deposited on the mist eliminator surfaces, continues to react with the exit gas and forms products hard to wash off.

Fewer problems with fouling of mist eliminators have been experienced with lime slurry systems. These normally operate at an alkali utilization of about 90 percent, whereas limestone slurry systems usually operate at much lower utilization values. However, it has been demonstrated at Shawnee that a limestone slurry system operated at high utilization, despite the accompanying reduction in SO_2 removal efficiency, will experience equal mist eliminator operability. This has been a major factor in redirecting the Shawnee program toward the investigation of chemical additives to overcome the loss of SO_2 removal when operating at low pH. However, there are other means to improve alkali utilization, e.g., three tanks in series and two-scrubber-loop operation.

11.3.2 Gypsum Saturation

As mentioned previously, proper selection of operating parameters, such as liquid-to-gas ratio, reaction tank residence time, pH, and percent solids in the recirculated slurry, to maintain a gypsum saturation level below about 135 percent will prevent gypsum scaling (Sections 3 and 4). This type of scaling in the mist eliminator is relatively easy to control by washing it with fresh water and diluted clarified liquor unsaturated with gypsum.

11.3.3 Flue Gas Velocity

As the gas velocity in the scrubber increases, more slurry is entrained and the load on the mist eliminator becomes greater. Furthermore, it becomes more difficult for the captured slurry to drain from the mist eliminator blades against the upflowing gas. Eventually, a gas velocity is reached that will re-entrain the slurry from the top edges of the mist eliminator. At this reentrainment point, the mist eliminator efficiency is lost.

In neither scrubber could the velocity be increased to the point that reentrainment occurred. Because of the limited fan capacity, maximum superficial gas velocity tested in the spray tower was 9.4 ft/sec. For the TCA, the maximum superficial gas velocity in the scrubber section was 12.5 ft/sec. This was equivalent to 8.2 ft/sec in the enlarged mist eliminator section. However, it is doubtful if the gas uniformly spread in the expansion section from the scrubber to the mist eliminator.

11.3.4 Slurry Solids Concentration

As the slurry solids concentration increases, the load on the mist eliminator increases. The majority of the Shawnee runs were made at 8 to 15 percent by weight slurry solids concentration.

11.3.5 Mist Eliminator Wash Systems

One of the most critical factors in maintaining reliable mist eliminator operation is the washing system. Slurry solids intercepted by the mist eliminator must be flushed away or the solids will build up and plug the mist eliminator. The amount of water available for washing the mist eliminator is limited, by material balance, to water losses from the scrubbing system (mainly flue gas humidification losses and losses with the disposed solids). In a scrubbing system with a tightly closed water loop (Section 10) makeup water is severely limited.

Over the operating life of the Shawnee Test Facility the mist eliminator wash sequence and spray pattern have been continually refined. By June 1976 the wash sequences and spray patterns as detailed in Table 11-1 were being used. Since that time plugging of any degree has been nearly eliminated. These wash sequences take into consideration the available makeup water with the tightly closed water loop at Shawnee.

The mist eliminators are, in their current mode, washed from both the bottom and top sides. The primary wash is from the bottom side with only a periodic flush from the top side. Because the TCA is square and the spray tower was circular, a different arrangement of nozzles is used in each scrubber to maintain full coverage. However, the wash sequence and specific wash rate (gpm/sq.ft.) for the two scrubbers are identical. In all cases Type 316 stainless steel full-cone spray nozzles are used.

From June 1977 to June 1978 the venturi/spray tower mist eliminator was cleaned once (December 1977) after 4183 hours of operation. At that time

Table 11-1

MIST ELIMINATOR WASH SYSTEMS

Alkali Alkali utilization	Lime or Limestone Greater than 85 percent utilization		Limestone Less than 85 percent utilization	
Scrubber system Maximum flue gas rate, acfm @ 300°F	Spray Tower 35,000	TCA 30,000	Spray Tower 35,000	TCA 30,000
Bottomside M.E. Wash				
Wash scheme	Low Intermittent	Low Intermittent	Continuous	Continuous
Nozzle size and model(1)	1/2 G35W	1-1/4 H190WSQ	1/2 G35W	3/4 HH71WSQ
Number of nozzles	10	2	4	2
Nozzle location, inches below M.E.	10	31	20	31
Nozzle "On" time, min	6	6	Continuous	Continuous
Nozzle "Off" time, min	234	234	-	-
Total on/off sequence, hr	4	4	-	-
Nozzle ΔP, psi	50	41	21	20
Flow rate per nozzle, gpm	7.5	37.5	5.0	10
Total flow rate, gpm	75	75	20(3)	20(3)
Specific wash rate, gpm/ft^2	1.5	1.5	0.4	0.4
Makeup water (continuous basis), gpm	1.9	1.9	20(3)	20(3)
Topside M.E. Wash				
Wash scheme	Low Intermittent	Low Intermittent	High Intermittent	High Intermittent
Nozzle size and model(1)	3/4 H6W	3/4 HH71WSQ	3/4 H6W	3/4 HH71WSQ
Number of nozzles	6	6	6	6
Nozzle location, inches above M.E.	16	15	16	15
Nozzle "On" time, min(2)	4	4	3	3
Nozzle "Off" time, min	76	76	7	7
Total on/off sequence, min	80	80	10	10
Nozzle ΔP, psi	13	13	13	13
Coverage area per nozzle, ft^2	15	14.5	15	14.5
Flow rate per nozzle, gpm	8	8	8	8
Specific wash rate, gpm/ft^2	0.53	0.55	0.53	0.55
Makeup water (continuous basis), gpm	0.4	0.4	2.4	2.4

Notes:
(1) All nozzles are full cone type manufactured by Spraying Systems Co.
(2) Sequential wash with one nozzle activated at a time.
(3) Clarified liquor from dewatering system diluted with all available makeup water.

the mist eliminator was 15 percent plugged due to a short-term malfunction of the wash system. The venturi/spray tower mist eliminator has operated another 3308 hours since that time without plugging; in June 1978 the restriction was less than 1 percent (Section 23.1.1, Reference 5).

The TCA mist eliminator was cleaned on June 21, 1978 when solids accumulations on the ductwork above the mist eliminator broke loose and restricted the mist eliminator by 12 percent. At that time, the mist eliminator had logged 7671 operating hours without cleaning.

Mist Eliminator Wash Scheme at High Alkali Utilization. When operating under conditions giving a high alkali utilization, i.e., with lime and limestone above about 85 percent alkali utilization (moles SO_2 removed/mole alkali added), a periodic flush with makeup water was all that was required to maintain clean mist eliminator surfaces.

On the bottom side the mist eliminator was flushed intermittently for 6 minutes every 4 hours with makeup water at a specific wash rate of 1.5 gpm/ft^2 of mist eliminator cross-sectional area. Pressure drop across the nozzles was about 40 to 50 psi.

On the top side a low intermittent sequential wash was used with 6 spray nozzles, in which one nozzle was activated at a time for 4 minutes every 80 minutes at a specific wash rate of 0.5 gpm/ft^2. Pressure drop across the nozzles was 13 psi.

Total makeup water consumption with this low intermittent wash scheme was equivalent to only 2.3 gpm on a continuous basis. This level of makeup water consumption was significantly less than the makeup water availability of 4-15 gpm (Section 10), demonstrating the importance of high alkali utilization. Typically at high alkali utilization and with this low intermittent wash scheme, the mist eliminator remained clean and showed only minor dust-like deposit.

Mist Eliminator Wash Scheme at Low Alkali Utilization. As the alkali utilization decreases in limestone systems, the mist eliminator becomes progressively more difficult to keep clean and a continuous underside wash is required.

Generally, for runs with a limestone utilization below 85 percent, the bottom side of the mist eliminator was washed continuously at a specific wash rate of 0.4 gpm/ft^2 using clarified liquor from the dewatering system diluted with all available makeup water. Pressure drop across the nozzles was about 20 psi. Clarified liquor was used because of the limited availability of makeup water in a closed-loop scrubbing system. Clarified liquor from the dewatering system is normally saturated in dissolved solids and must be diluted with makeup water to prevent scaling of the mist eliminator. Proportions as high as 80 percent clarified liquor and 20 percent makeup water have been used with no apparent scaling. Even with this dilution factor, assuming the undiluted clarified liquor is 100 percent saturated with gypsum, the diluted liquor would be about 65 percent saturated with gypsum, which is well below the incipient scaling point of 135 percent.

The top side wash was a high intermittent sequential wash with makeup water, in which each of the 6 spray nozzles was activated in sequence for 3 minutes every 10 minutes at a specific wash rate of 0.5 gpm/ft^2. Pressure drop across the nozzles was 13 psi.

All available makeup water was used with 2.4 gpm as top side wash and the remainder as clarified liquor diluent to the bottom side wash.

Some mist eliminator restriction with soft solids was experienced with the above described wash scheme at low limestone utilization. However, the restriction would reach a steady-state level rarely above 10 percent and usually below 5 percent.

11.4 OPERATING CHARACTERISTICS OF SHAWNEE MIST ELIMINATOR

11.4.1 Pressure Drop

Typical pressure drops across the three-pass, open-vane, 316L S.S. chevron mist eliminator were as follows:

Scrubber	Gas Rate acfm @ 300°F	M.E. Superficial Gas Velocity, ft/sec @ 125°F	Mist Eliminator ΔP, in. H_2O
TCA	30,000	8.2	0.4 to 0.6
	20,000	5.5	0.1 to 0.2
Spray Tower	35,000	9.4	0.5 to 0.7
	25,000	6.7	0.2 to 0.4

11.4.2 Entrainment

Of course, the cleanest of mist eliminators is of no significance if it does not do its primary job of removing slurry entrainment. In April and May 1977 air/slurry tests were performed on both the venturi/spray tower and TCA systems in an attempt to determine the amount of slurry entrained through the three-pass, open-vane mist eliminator. Conditions were less than ideal. The inlet air dust concentration was high, and traces of the No. 2 reheater oil were noted in the TCA outlet. Corrections were made for the presence of oil, but there was no way to determine how much the inlet dust contributed to outlet mass emissions and how much came from entrainment. The following outlet mass emissions were measured.

Scrubber	Slurry Rate, gpm	Flue Gas Rate, acfm @ 300°F	M.E. Superficial Gas Velocity, ft/sec @ 125°F	Outlet Mass Loading, gr/dscf
TCA	1200	30,000	8.2	0.001 - 0.005
Venturi/ Spray Tower	1400	35,000	9.4	0.001 - 0.003

The range of TCA outlet mass loading was obtained from 20 sets of data points under 4 sets of test conditions, whereas the venturi/spray tower from 15 sets of data points under 6 sets of test conditions. Although the data may not be accurate because of the problems with dust and oil traces, a general idea on the order of magnitude of slurry emission was obtained.

Section 12

OPERATING CONSIDERATIONS

12.1 HOT GAS/COOLING SLURRY INTERFACE

Because of the complex, three-phase flow and simultaneous evaporation conditions existing at the hot gas/cooling slurry interface, careful attention must be given to the gas inlet duct design, cooling nozzle selection and arrangement, and soot blower design.

At Shawnee the hot (300°F) flue gas feed is humidified before entering the neoprene-lined TCA scrubber to reduce the gas temperature below 190°F, the maximum permissible for liner protection. Normally, the gas temperature is reduced to about 150°F. For the venturi scrubber inlet, cooling of the feed gas is not required during normal operation; the venturi scrubber itself is an efficient humidifying device.

The solids buildup problem experienced during the early days in the TCA inlet duct was solved by careful selection of nozzle size and type, orientation, location and the number of cooling slurry nozzles (Reference 1, Section 10.4). This effort was supplemented with modification of the soot blower head (both nozzles facing forward at a 45° angle), the soot blowing cycle (air blowing during forward travel only) and installation of a Y-Strainer in the process slurry line to the cooling spray nozzles. With these modifications the wet-dry interface was moved to within 12 inches of the scrubber entrance, from where the accumulated solids could be easily blown into the scrubber and discharged through the 48-inch downcomer for reslurrying in the effluent hold tank.

12.2 FIELD LABORATORY pH MEASUREMENT

A detailed report covering the tests, recommendations, and subsequent results of using improved procedures for laboratory pH measurement (in the field sampling laboratory located on the scrubber structure) was issued in September 1976 (Reference 23). Discussion of in-line process pH meters (referred to as "meter pH" as opposed to the "laboratory pH") can be found in Section 13.7.1.

Measurement of laboratory pH in slurry liquor at the Shawnee Test Facility was subject to frequent unexplained pH excursions, and there was a high rate of pH electrode failure before the situation was brought under control in the spring of 1976. This situation was tolerable during runs lasting many days but became unacceptable during short-term factorial tests. These tests required changing the run conditions every 6 to 8 hours and controlling slurry liquor pH within 0.1 pH unit.

An intensive study of the laboratory pH measurement procedure in February and March 1976 revealed that variability of laboratory pH data in the past was due primarily to thermal cycling (cold buffer to hot slurry) of the electrodes and to fouling of the reference electrode junction by slurry solids. An analysis of the problem produced a number of recommendations for improved quality control, all of which were implemented.

A fully enclosed heated and air conditioned field laboratory was constructed on the scrubber structure to facilitate sampling. A pH meter (Fisher Model 520) with digital readout (to 0.001 pH unit) was used in the field laboratory after March 1, 1976.

Use of laboratory-prepared (homemade) buffers was discontinued at the facility; certified buffers with known temperature dependence were used for buffering of all glass electrodes. More importantly, off-line electrodes were stored at pH 4 in hot (50°C) solutions saturated with potassium chloride (KCl). This method of storing electrodes between service periods had three important functions:

- The hot (50°C) solution minimized thermal stress by holding the electrodes at a constant temperature while on-line or off-line. With this method of storage, repeated cycles of heating and cooling were eliminated.
- The saturated solution of KCl increased life expectancy of the electrodes by preventing reference cell dilution.
- The low pH (pH 4) of the solution reduced reference junction fouling by preventing buildup of acid-soluble solids on the cell surfaces during storage. It also kept the glass membrane sensitized.

The slurry liquor pH reading procedure was further improved by using two electrodes (one for each scrubber system), switching the electrodes at the beginning of each 8-hour shift, allowing a constant 4 minutes per reading whether in the slurry or in the buffer, and renewing the buffer solution at the beginning of each day shift.

Use of electrodes with rubber-stopper connections was discontinued following the pH study at Shawnee. Uniloc and Broadley-James combination electrodes, both with glass-to-glass seals, were used after March 1976. These electrodes performed well. Quality control criteria required an electrode to be discarded either if it could not be zeroed at the correct buffer pH with the pH meter control, or if it did not agree (within 0.2 pH unit in a slurry sample) with two new electrodes used for comparison purposes. In addition, onsite personnel were instructed to investigate the discrepancy if the field laboratory pH and in-line process pH ("meter pH") values disagreed by more than 0.2 pH unit for more than 2 hours.

The improved procedures outlined above were practiced at Shawnee after March 1976 with very good results. Electrode life was measured in months instead of weeks, and virtually no problems or inexplicable pH variations were encountered.

12.3 REHEAT

An important consideration common to all wet scrubbing systems is the dispersal of the wet scrubbed gas. The most common practice is to heat the wet gas to impart buoyancy. Methods of reheat include direct oil-fired systems, steam heated coils, and indirect reheat systems in which the hot gas is generated in a separate combustion chamber and subsequently mixed with the flue gas. At Shawnee the original direct oil-fired system was modified to an indirect reheat system with an external oil-fired combustion chamber for improved reliability (Section 13.3). The degree of reheat required varies with the height of the stack, the nature of the surroundings, the efficiency of the mist eliminators, the desire to minimize steam plume, the prevailing ambient temperature and other meteorological conditions such as dew point, wind speed, wind direction, etc. Common U.S. design practice has been to provide 50 to 75°F of reheat.

At Shawnee, the reheater operation has never been optimized. The degree of reheat is knowingly overkill at 125°F. This high level of reheat is maintained primarily to prevent SO_3 condensation, to protect the outlet ducting and the induced draft fan, and to minimize the scrubber downtime due to the failure of downstream equipment.

Section 13

EQUIPMENT OPERATING EXPERIENCE DURING LIME/LIMESTONE TESTING

This section summarizes the equipment operating experience during lime/limestone testing during the Advance Testing Period from October 1974 through June 1978, with both high and low fly ash loading in the flue gas, with and without magnesium addition, and with and without forced oxidation. Readers who are interested in more detailed information are referred to References 2 through 5.

13.1 SCRUBBER INTERNALS

13.1.1 Mist Eliminators

Descriptions of the mist eliminator systems tested and the results of those tests have been summarized in Section 11.

13.1.2 TCA Grid Supports

The 3/8-inch diameter, Type 316L stainless steel grids, installed at 1-1/4 inch centers, were in slurry service for approximately 5 years with no evidence of significant erosion. After 4 years two bars in the bottom grid exhibited signs of corrosion. These bars were analyzed and determined to be

Type 409 stainless steel, mistakenly installed during a sphere change.

13.1.3 TCA Spheres

Several types of spheres were tested on the TCA system. A summary of their respective performances has been presented in Section 9.1.4.

13.1.4 TCA Slurry Nozzles

The four main slurry spray nozzles in the TCA are full-cone, open-type nozzles, manufactured of Type 316 stainless steel by Spraco, Model 1969F. During 5 years in service, the nozzles provided excellent service both in terms of wear and non-clogging characteristics. Over the years, only a small amount of erosion occured at the discharge orifice. The insignificant wear rate is attributed to the low pressure drop (about 5 psi) across the nozzles.

The three inlet gas cooling spray nozzles were manufactured by Bete, No. ST32FCN (full-cone), with Stellite diffusers (spiral tip). After 11,600 hours of operation the diffusers of two nozzles were so eroded that only one complete turn of the spiral tip remained. The three nozzles were replaced with identical units.

13.1.5 Venturi Internals

The variable throat venturi scrubber (Figure 9-12), made of Type 316 stainless steel, experienced both stress corrosion cracking and erosion during the Advanced Testing Period, a continuing problem since 1972.

Inspection after three years of testing (during the May 1975 boiler outage) revealed stress cracking on the portion of the inlet duct that extends into the venturi; a 4-inch wide half circle of duct had fallen off. An 8-inch hairline crack was also discovered in the venturi housing at the point where the bull nozzle entered the venturi. The stress cracking did not appear serious and was repaired by welding. Severe erosion was also noted on the plug shaft protection shroud and guide vanes. The erosion was severe enough to require steps to prevent damage to the plug shaft itself. The most successful repair method was to cover the affected areas with an expendable material that could be replaced periodically. The most suitable material was neoprene, which lasted up to 2000 hours.

After the May 1975 boiler outage two more pieces of the 40-inch duct extension at the venturi inlet failed, and erosion of the bull nozzle, plug guide vanes, and plug shaft sleeve flanges continued. To prolong the life of the guide vanes and to test materials of construction, the vanes were covered with metal wear plates or rubber shields (Reference 3, Appendix L).

In 1976, blisters were observed in the rubber lining of the 4-inch piping to the tangential nozzles and the bull nozzle. One such blister was slit for attempted repair with epoxy, but this technique was not successful. The rubber was cut out, and the affected area was successfully repaired by coating with epoxy.

In January 1977, minor repairs were made to the venturi plug guide vanes and the shroud. Repairs were also made to the rubber lining in the venturi flooded elbow. An inspection of the venturi in March 1977 showed serious abrasion of a section of the guide vane structure that had previously been repaired. The protective rubber covering over the four guide vanes had failed to varying degrees and was replaced with new covering. Maintenance also included the replacement of the venturi bull nozzle in December 1977 and the patch repair of the venturi inlet gas duct in February 1978. Solids or scale deposits in the venturi or the flooded elbow were usually minor and were never associated with mechanical or erosion problems. It should be emphasized that solids buildup at the gas/slurry interface in the venturi entrance was also never significant.

13.1.6 Spray Tower Slurry Nozzles

Two types of slurry nozzles were tested in the spray tower: Bete No. TF48FCN Type 316 stainless steel nozzles and Bete No. ST48FCN Type 316 stainless steel nozzles with Stellite diffusers. The "TF" nozzles were made out of one piece of stainless steel whereas the "ST" nozzles consisted of three pieces: the base and collar nut of Type 316 stainless and the diffuser of Stellite.

Eight Bete 316 stainless steel nozzles (No. TF49FCN) were tested for 1565 hours on lime slurry with low fly ash loading. During the test period the average flow rate per nozzle was 45 gpm at 10 psi pressure drop. Most of the operation, approximately 1200 hours, was with 8 percent solids slurry. The remainder was with 4 percent solids slurry. During the testing individual nozzles lost from 0.93 to 2.43 percent of their initial weight due to erosion.

Most testing on the spray tower during the Advanced Test Program was with Bete No. ST48FCN nozzles with Stellite diffusers. These nozzles were installed in March 1974. They provided almost uninterrupted service till their removal in 1976. Twenty-seven nozzles (7 nozzles/header on the top 3 headers and 6 nozzles on the bottom header) were used during the 17,500-hour test period. Only two nozzles had to be replaced during the test period.

In removing the Stellite diffusers for inspection at the end of the 17,500-hour, the impact of the pipe wrench on the collar nut connecting the diffuser to the base of the nozzle fractured ten of the diffusers near their tips. Inspection of these nozzles revealed that the major portion of the nozzle wear was confined to the diffusers. After 17,500 hours of testing the average thickness of the diffuser decreased from 0.260 inch to 0.193 inch, which represents a reduction of 26 percent. The maximum erosion of the base, measured by a diameter increase, was 20 percent after 10,685 hours of service.

New Stellite diffusers were installed in January 1977. In March 1977 after a total of 2649 hours, 973 hours of which were in limestone service and 1676 hours in lime service, the diffusers were found to have negligible pitting and relatively uniform wear as shown by measured thickness of the reference area of four randomly selected diffusers:

4th level (upper)	0.253 inch
3rd level	0.223 inch
2nd level	0.220 inch
1st level (lower)	0.217 inch

These findings illustrate that flow rates through the four headers were approximately equal with a possible reduced flow rate at the fourth level. The metal used for these diffusers, Stellite VI, contains 25 percent chromium, 5 percent tungsten, 1 percent carbon, and 69 percent cobalt.

Service life of about 2 years for the ST48FCN nozzles is considered very satisfactory under moderate pressure drop of about 10 psi. Occasional plugging by loose scales of these nozzles was experienced due to malfunction of the strainers located upstream in the slurry line.

13.1.7 Spray Tower Trapout Funnel

Separation of slurry leaving the venturi scrubber from that leaving the spray tower is necessary in some cases to achieve independent scrubber loops for forced oxidation testing. This flow separation is accomplished by a large trapout funnel installed in the spray tower below the bottom level of spray nozzles (see Figure 6-1). Flue gas moves upward around the funnel periphery through the one-foot annular space at the wall of the spray tower and is then deflected over the funnel by an annular ring attached to the tower wall. The annular ring also serves to direct falling slurry spray from above into the trapout funnel. It should be noted that a trapout funnel is not necessarily an efficient or practical mean of separating slurries in a full-scale plant, but it was expedient at Shawnee. Widespread use of a trapout funnel in full-scale plants would not be expected.

No evidence of corrosion was observed on the funnel, which was constructed of Type 316L stainless steel.

During normal operation, accumulations of solids on the underside (gas side) of the funnel were a common occurrence. After one limestone forced oxidation run, nearly complete plugging occurred on one portion of the funnel. Solids grew progressively on its outer edge until they were only a few inches from the bottom of the deflector ring. No solids accumulated on the inside of the funnel and no interference with slurry flow through the funnel downcomer was noted.

13.2 OXIDIZERS

13.2.1 Air Spargers

The slurry oxidation system (Section 6) consists of an air bubbler in the tank bottom and a slurry agitator. The oxidation tanks are tall and thin (7 to 8 feet diameter x 20 feet high) to provide long air/slurry contact time.

The first air sparger was an octagonal ring with 130 1/8-inch holes pointed downward and was installed near the bottom of the oxidation tank of the venturi/spray tower system (see Figure 6-2). Inspection of the sparger after 1745 hours of service revealed that 54 air holes were badly eroded, 33 were slightly eroded, and 65 were plugged with hard scale. This sparger was replaced by a sparger ring of the same size but having 40 1/4-inch holes. Inspection of the new sparger ring after 2400 hours of operation indicated that a spool piece connecting the sparger ring and the compressed air source was completely eroded through and that most of the air had been escaping from the holes in the spool piece. Type 304 stainless steel had been erroneously used as the spool piece material. Despite the non-uniform distribution of air through the spool piece, high oxidation efficiency was achieved during this test period.

Based on this discovery, the air sparger ring was replaced with a 3-inch diameter pipe extending to the center of the tank. Air was discharged downward through a 3-inch elbow at the end of the pipe. Oxidation efficiency continued to be high with this arrangement, indicating that the agitator played a key role in providing air/slurry contact. The agitator used was a 20 Hp axial down-flow agitator rotating at 56 rpm.

The venturi/spray tower sparger ring with 40 holes of 1/4-inch diameter was installed in the TCA oxidation tank (see Figure 6-8). The ring, constructed of 316L stainless steel, was in good condition except for minor erosion at the 1/4-inch air holes. A conventional tank agitator (37 rpm, 3 Hp) was used for mixing. Despite marginal air/slurry contact with weaker agitation, near complete oxidation was achieved with this configuration. Future tests, designed to determine power requirements, will use a variable speed agitator.

13.2.2 Oxidation Air Compressors

A Worthington type VBB, size 14-1/2 x 9 inch, single cylinder air compressor with 100 Hp motor was used for both venturi/spray tower and TCA systems during the Advanced Test Program. The compressor selected was an oil-free, non-lubricating type to avoid possible contamination of slurry by the oxidation inhibitors in the oil.

Maintenance requirements were negligible. The cooling water jackets were periodically flushed to remove soft scale.

13.2.3 Penberthy Eductor

An eductor is a device that passes a high velocity slurry through a constricted nozzle into an eductor chamber and then through a moderately restricted jet throat. In the chamber, the slurry creates a vacuum that draws ambient air into the chamber via an entry pipe located at right angles to the slurry flow path. The air is then entrapped and mixed in the slurry as the fluid leaves the eductor chamber and passes through the jet throat.

At Shawnee, a Penberthy Model ELL-10 Special eductor was tested. The materials of construction were Stellite for the nozzle and a whirler inside the nozzle, and neoprene-lined carbon steel for the eductor chamber and exit jet throat. The eductor was normally operated at 1600 gpm slurry flow rate.

Test results indicated near-complete oxidation, but serious erosion problems were noted. The neoprene lining in the jet throat was chipped off after only 620 hours of operation. After approximately 1800 hours of operation, bare carbon steel was exposed. Tests were terminated after 2055 hours of operation when an epoxy patch failed. In view of cost disadvantage compared to simple air sparge systems and severe erosion problems, further testing of the eductor is not planned.

13.3 REHEATERS

Scrubbed flue gas was reheated to prevent acid condensation and corrosion in the exhaust system, to facilitate analytical sampling, to protect the induced-draft fans from solid deposits and droplet erosion, and to increase plume buoyancy.

The original in-line, fuel-oil-fired units supplied by Hauck Mfg. Co. experienced frequent flameout and incomplete oil combustion. The Hauck reheaters were modified in March 1974 (venturi/spray tower) and May 1975 (TCA) to incorporate a fuel-oil-fired external combustion chamber manufactured by Bloom Engineering Co. Both units operated reasonably well following the modifications with only periodic flameout and minor electrical problems.

13.4 INDUCED-DRAFT FANS

The Type 316L stainless steel fans at the Shawnee Test Facility are induced-draft, centrifugal fans manufactured by Zurn Industries. Reliability was fair to good during the Advanced Testing Period, with the only system downtime being due to the following fan problems:

- Occasional cleaning of the fan, fan dampers, and duct between the dampers and reheaters.
- Replacement of the I.D. fan outboard bearing and pillow block, 8 times for the two fans.
- Replacement of the motor on the Beck damper position control on five occasions.
- Servicing and adjusting the damper control linkage.
- Repairing a 4-inch hairline crack on the venturi/spray tower fan rotor. The crack was successfully repaired by welding with a Type 347 stainless steel rod and grinding the weld smooth. Initial repair using a 316L stainless steel welding rod was not successful.

13.5 PUMPS

13.5.1 Allen-Sherman-Hoff Pumps

The Allen-Sherman-Hoff centrifugal pumps are neoprene lined, slurry service pumps equipped with Nelson liquid drive units. The pump packing was conventional graphite-impregnated asbestos. The sleeves were chrome-plated steel. Pump seals were air-flush type used to prevent excess water input to the system.

In light of the wide range of operating conditions experienced, it must be acknowledged that the pumps provided satisfactory service and required only moderate maintenance. The most frequent maintenance was repacking. Although there was no apparent pattern associated with repacking frequency, the following general trends were observed:

- Wide flow variation as dictated by changing test conditions increased repacking frequency.
- Operation of a pump at the low-flow end of the pump curve accelerated the frequency of packing problems.

Somewhat less frequent but routine pump maintenance included fluid change in the vari-drive, replacement of the fluid cooler on the vari-drive, and replacement of pump sleeves.

13.5.2 Moyno Pumps

Moyno pumps are positive displacement, variable speed pumps used primarily for moving thick slurry at Shawnee. Five such pumps are employed as alkali addition pumps. A larger sized Moyno is used to recirculate underflow slurry in the TCA clarifier. The latter pump experienced limited service.

Moyno pump rotors are helical shaped and are made of chrome-plated steel for abrasion resistance. Stators are rubber-lined with a double helical groove. The most frequent maintenance problem was erosion of pump stators. An infrequent problem was the loss of pump capacity due to erosion of the rotor surface after what appeared to be a chrome plating failure. The pumps were oversized by a factor of two. They were allowed to wear until the required flow could no longer be maintained. Typical operating life for a stator and rotor was 1000 and 2000 hours, respectively.

13.6 ALKALI ADDITION SYSTEMS

13.6.1 Lime

The slaked lime preparation system consists of a pebble lime storage silo, a screw feeder, a Portec-Cahaba lime slaker, a slaked-lime holding tank and associated feed pumps. Fresh water is used to slake the lime to a slurry of approximately 20 weight percent solids. The system has exhibited good reliability, once its early startup problems were overcome.

Over the years minor modifications have been made and some maintenance has been performed. Activities worth noting were:

Modifications

- The original (vendor supplied) nozzles in the sprays for the grit screen were replaced with more open nozzles to increase the spray flow rate.
- The grit screen drive bearings (2 sets - 1-1/2 inch and 1-5/8 inch), were replaced with Dodge type E pillow block bearings.
- Larger slaking water control valves and larger sprockets for the lime screw feeder were installed to increase capacity.
- The lime slurry sump pump start/stop float linkage was replaced with an improved version to prevent damage to the mercury switch controls.
- An alarm was installed at the control board to notify the operator of screw feeder stoppage.

Maintenance

- The slaker (grit) screen has been replaced only 18 times in nearly 7 years of operation since 1972. Carbon steel screens tend to wear out from grit abrasion and from the hydro chloric acid used periodically to remove carbonate scaling on the screens.
- The slaker screen motor has been replaced twice, the drive shaft once, the bearings once and the motor over-heat detector once.
- The slaker process control elements have been cleaned and serviced once, the unit painted once, and the air leaks the lime silo baghouse repaired once.

13.6.2 Limestone

The limestone slurry preparation system consists of a limestone drying/grinding system, four limestone bins, a weigh belt feeder, a limestone slurrying/surge tank, and associated feed pumps. (The drying/grinding system came from an earlier EPA Dry Limestone Injection Project which preceded the present wet scrubbing program.)

For slurrying purposes, pulverized limestone from the grinding system is pneumatically conveyed to a 1-day storage silo from where it is belt-fed into the 400 gallon limestone slurry preparation tank. Slurry solids concentration is controlled at nominal 60 weight percent.

In view of the system usage, it can be said to have provided acceptable performance with moderate maintenance. Most of the maintenance has been asssociated with the drying/grinding system. The major maintenance activities were as follows:

- Equipment vibration resulted in damage to the electronic components circuit boards of the fuel oil and dryer temperature controllers. New controllers with more vibration resistant mounting were installed.
- Refractory in the burner section of limestone dryers was patched in April, October, and November, 1977. Kaocrete B has been used successfully.
- The Graham three-taper pin assembly in the variable speed drive for the limestone dryer feedbelt was repaired and was subsequently replaced.
- The oil atomizing air compressor for the limestone dryer has been repaired once.
- The ball mill feeder circuit, magnetic starter for feed belt motor, and fuel oil controller circuit board were replaced.
- The gear box on the limestone mixer feedbelt has been replaced once.
- The top impeller of the mixer in the limestone slurry preparation tank has been adjusted and spaced properly on the shaft to improve continuous mixing of the ground limestone and water.

13.7 INSTRUMENT OPERATING EXPERIENCE

13.7.1 In-line pH Meters

Process pH is measured using Uniloc Model 312L submersible electrode assemblies (See Section 12.2). These assemblies are manufactured by Universal Interloc, Inc., of Santa Ana, California. Originally, Uniloc Model 320 flow-through meters were used, but because of line plugging problems and frequent sensing electrode breakage, use of these type sensors was abandoned.

Service requirements for the submersible assemblies consist of periodic cleaning and buffering of the electrodes, generally every 2 or 3 days to ensure accuracy. Also, to minimize the service requirement, the instrument electrodes are placed in water during scrubber outages. On infrequent occasions the electrode assembly has failed due to assorted reasons, such as wet electrical contacts or bad reference or sensing electrodes. The principal continuing service requirement of the Model 321L pH meters has been scale removal from the probes. The frequency of cleaning has depended on the operating conditions of the scrubber and has ranged from once every few days to once every few weeks. This scale causes measurement error and can be removed with hydrochloric acid. All probes are also routinely rinsed with water at least twice a week. A short test was conducted in April 1975 using a continuous ultrasonic cleaner for the prevention of scale buildup. The cleaner was effective at preventing heavy scale buildup.

To ensure the accuracy of the process pH meters, a laboratory pH measurement (with a portable pH meter, see Subsection 12.2) is made once every two hours for comparison purposes. This procedure enables pH control to be maintained within ± 0.2 pH units of the desired set point.

13.7.2 SO_2 Analyzers

A Du Pont Model 400 UV split-beam photometer, equipped with an automatic zeroing and air purging system (1 minute every 10 minutes frequency), is used to measure SO_2 concentrations. The instrument has been accurate and reasonably trouble-free. Maintenance requirements have been limited to cleaning the sample cell and sample lines approximately once every 1 or 2 months and to cleaning the particulate filter about once every 3 to 4 weeks. In addition, the optical filter is calibrated twice per week, and the instrument is calibrated against the calibration gas once per week with a simultaneous check of the optical filter. Ultraviolet lamp failure has been the only component problem and is caused by uncontrollable and momentary power fluctuations resulting from switching of station power. An effective particulate filter for the instrument is a cylindrical chamber constructed of a fine mesh screen. The screen cylinder is surrounded by a solid protective cylinder. The gas sample lines operated leak free; the lines are of heat traced Teflon tubing.

13.7.3 In-line O_2 Analyzer

Oxygen concentration in the inlet flue gas is measured with a Teledyne Model 9500 meter which was put in service on June 15, 1977. The meter uses a micro-fuel cell as the sensing element. Based on a year's operating experience the overall sampling and instrumentation performance has not been satisfactory. Pertinent problems included:

- Five fuel cell failures with a cell life range of 1 to 30 days.
- Two sequence mechanism failures.
- Two solenoid valve failures.
- Freezing of instrument scrubbing water supply.

The unit operated for less than six weeks total time during the year of testing.

The test facility currently uses four Thermox O_2 analyzers which were installed in November 1978 at inlets and outlets of the venturi/spray tower and TCA.

13.7.4 NO_2 Analyzer

Another Du Pont Model 400 UV photometer was modified by Du Pont technicians in 1976 to analyze for NO_2, which constitutes a small fraction of total NO_x. Over a 14-month period no useful data was obtained due to an erratic output signal. Numerous modifications and checks have been performed by Du Pont representatives but the source of the problem has not been located. The installation is therefore judged to be a complete failure.

13.7.5 Magnetic Flowmeters

The original 1-1/2 inch Foxboro magnetic flowmeters, Series 1800, were lined with Scothane that rapidly deteriorated in service. Subsequently, the meters were relined with Adiprene-L. The new liners failed after periods ranging from 3 to 9 months due to blister formation, subsequent erosion of the blister, and eventual stripping away of the liner. It was then noticed that these liners were tapered in thickness near the meter exit. The meters were relined with Adiprene-L of uniform thickness in September 1975, after which no liner failures were experienced. Larger meters (6 to 8-inch size) were lined with neoprene. No difficulties with liner deterioration were experienced with the neoprene-lined meters.

In 1976 Foxboro discontinued manufacture of the Series 1800 meters used at Shawnee. The company now offers a more compact Series 2800. These Series 2800 magnetic flow meters, 1-1/2 inch or smaller, are lined with Teflon rather than Adiprene-L. The Teflon liner has performed satisfactorily.

Periodic scale removal is required to maintain accuracy and sensitivity and on infrequent occasions the magnetic converter requires maintenance. Satisfactory meter accuracy is maintained by electrical purging once per shift with the Foxboro Magnetic Flow Meter Electrode Cleaning Assembly. The electrode cleaning assembly applies line power voltage between the transmitter electrodes and the transmitter tube. The current flow oxidizes away electrode deposits and thus removes the condition of high resistance between electrodes and the process liquid for normal accurate operations. The meters are considered reliable, acceptably accurate, and easily serviced.

13.7.6 Density Meters

Both Dynatrol Model CL-10HY U-tube density meters and Ohmart radiation density meters are used at Shawnee. Although the U-tube density meters are preferred, both types of meters provide acceptably accurate and dependable service. The instruments are used primarily for monitoring trends in slurry density values. Initially the U-tube meters experienced plugging problems. The cause was attributed to operator misjudgement in setting too low a flow through the instrument. Improved performance has been noted after the operating personnel were properly trained.

13.7.7 Level Measurement

Three Brooks Maglink 5300 Series level indicators were installed in three scrubber effluent hold tanks for evaluation. The Brooks indicator consists of a vertically mounted standpipe fastened externally or internally to the side of a tank, with a bottom liquor inlet to the chamber. Slurry level is detected by a donut-shaped float surrounding a small center pipe running the length of the stilling chamber. A magnet inside the sealed center pipe moves with the float and provides a level signal from its position.

The initial problem was solids buildup on the float, which led to eventual immobilization. A liquor flush stream was installed in an effort to eliminate the problem, but the following difficulties continued:

- Dislodging an immobilized float occasionally uncoupled the magnet.
- Altering the measurement range required the installation of a new gear drive.
- Floating material caused occasional immobilization of float.
- The flush system liquor stream impinged on the float causing float depression and reading error. The magnitude of the error was variable and depended on the distance the purge stream free fell prior to impingement on the float.

When working properly, the Brooks indicator measured slurry level in the effluent hold tank to within 6 inches. However, solids clogging the standpipe and float were a common occurrence.

The most widely used level indicators were the Foxboro differential pressure (atmosphere/tank pressure) Model 617 FEM with Teflon coated stainless steel diaphragm. The instruments had three recurring problems:

- Deposits of mud or scale on the diaphragm caused false readings. Cleaning of the diaphragm requires draining of the tank.
- Changes in slurry density changed the indicated level.
- Transmitter electronics were sensitive to the ambient temperature. Foxboro claims that the problem has been corrected on newer models.

13.8 OTHER MATERIALS AND EQUIPMENT EVALUATION

During the advanced Test Period the following equipment and materials were monitored:

- Lining and piping
- Control valves
- Strainers

13.8.1 Lining and/or Coatings

Lining and/or coating materials for equipment at the Shawnee Test Facility generally consist of neoprene (pipes, pumps, scrubber internal walls and small tanks) or Flakeline 103 (large effluent hold tanks and clarifiers). Flakeline 103 is a bisphenol-A polyester resin filled 25 to 35 percent with glass flake and is manufactured by The Ceilcote Company.

Both neoprene lining and Flakeline coating have shown only minor erosion or other deterioration. Whenever necessary, successful repairs have been made using Epoxylite-203 (Epoxylite Corp., Anaheim, California), an epoxy resin formulated with selected fillers. The resin was cured with Epoxylite's No. 301 amine hardener. For example, a patch on the venturi/spray tower effluent hold tank agitator blade showed only minor wear after more than 25,000 hours.

Testing of three test panels provided by Ceilcote Company was completed in 1976. Approximately one-third of the exposed surface of each panel was covered with one of three Ceilcote formulations: Flakeline 103, Caroline 505AR and Flakeline 151. All three formulations on the test panel mounted inside one of the TCA beds exhibited significant wear after 6634 hours of exposure.

In a 1976 test, selected areas of neoprene lining, glass surfaces and stainless steel surfaces (mist eliminator vanes) were cleaned and McLube No. 1700 coating was applied. This material is designed to keep ship hulls free of barnacles, and it was hoped the material would prevent solids accumulation. Results were unsatisfactory. The tops of coated mist eliminator vanes held more solids than did some uncoated vanes in the immediate vicinity. It is possible that the coating did not cure or dry exactly as desired.

Infrequent hardness measurements were made on areas of tower lining in contact with spheres or areas receiving direct spray impingement. The range of Durometer A hardness readings was 42 to 60 (at 65° to 90°F), as compared to 60 to 65 (at 73°F) original vendor's data. Higher temperature gives a lower reading. Generally, the lining was in good condition although the surface where scale was often removed exhibited scabs from chipping tools. There was no evidence of rubber lining separation from the metal substrate.

A test panel (20 x 15 x 3/8 inches) supplied by Pullman Kellogg, made of carbon steel and coated with fluoroelastomer CXL-2000, was installed in the inlet gas duct of the TCA scrubber for the purpose of determining the ability of the material to withstand the hot gas/slurry environment. It was arranged to have cooling slurry spray impinge across its face. Inspection of the panel after approximately 2000 hours in service showed that the coating had failed along the exposed flanged edge allowing erosion of the carbon steel substrate. Therefore, the material was judged to be unsatisfactory for the conditions under which it was tested.

Results of extensive and thorough materials evaluation work at Shawnee are included in the Five Reports on Corrosion Studies published by TVA (see Appendices of References 1, 3, 4, and 5*).

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*Reference 1 contains two reports.

13.8.2 Piping

After 5 years in service, blisters were observed in some sections of the neoprene lined pipe. However, these blisters did not precipitate pipe failures or blockage, and therefore did not lead to operating or maintenance problems.

During a number of system modifications, sections of plastic pipe and fittings were installed for evaluation in slurry service. Schedule 80 PVC 1120 (ASTM D-1785) piping of 6-inch and 8-inch diameters was installed for the TCA recirculating slurry lines. Fittings were all of standard radius design. PVC piping also served the venturi/spray tower oxidation tank system. Operation with PVC piping has been satisfactory, with respect to corrosion and erosion, over the limited time span of its use. However, some mechanical failures have been experienced due to impact of heavy objects.

A section of U-shaped Bondstrand, fiberglass-reinforced 8-inch plastic pipe was removed from service after approximately 8800 hours. It had been installed in the suction line of the TCA recirculating slurry pump. There did not appear to be significant wear of the pipe surface and the entire section was judged to be in excellent condition.

A section of 8-inch polybutylene pipe, having the same configuration as the Bondstrand pipe, was also installed in the suction line of the TCA recirculating slurry pump. There was no evidence of erosion in the polybutylene pipe after about 3550 hours of service.

13.8.3 Valves

A Valtek 6-inch butterfly control valve was located in the spray tower recirculating pump discharge line. Inspection after 3000 hours of service revealed hairline cracks in the valve body and some slight disc erosion. Flow rate control, at 700 to 800 gpm, was good. Inspection after 4853 total service hours (1551 hours wide-open and 3302 hours in throttling service) revealed small fissures in the body bore, up to 3/4 inch long, and a great amount of erosion in the lower half of the valve body. The two deepest grooves were 0.180 and 0.162 inch. In contrast to the body failure, the Stellite-coated disc showed some slight waviness of the disc edge thickness. Continued use of the valve resulted in further erosion of the valve body.

Previously observed grooves had deepened and the worst single hole located in the disk plane was 0.28 inch deep. Thickness measurements at the outer edge of the Stellite disk ranged from 0.22 to 0.24 inch.

A Fisher 2-inch Stellite butterfly control valve was originally installed in September, 1976, on a slip-stream from the spray tower recirculating pump discharge line. Inspection after 2 months of service indicated that the fish-tail disc was in excellent condition. Only slight erosion or rounding of sharp edges of the disk occurred, along with some slight pitting. Minor pitting was seen on the leading (upstream) edge along the rear face. Pitting was found to a greater extent on the back face than on the front face where a few pits were seen. A magnifier was needed to see these shiny pits, which were estimated to be 2 to 3 mils deep and 10 mils in diameter. The rear half of the disc (trailing edge) where the fish tail was located appeared to be in good condition. Minor erosion took place in the body of the valve in the plane of the closed disk position. The estimated maximum depth of wear was 0.5 mm. The valve body appeared to be wearing faster than the disk in throttling service. Six months after its installation, the valve was moved from the venturi/spray tower to the TCA system.

A Durco 6-inch butterfly valve with a high-density polyethylene-coated disc was located in the discharge line of the pump that fed the top two spray tower headers. A total of 3700 hours of service with 8 percent slurry at approximately 9 ft/sec slurry velocity through the valve (in full-open position) resulted in a 4.5-mil loss of the disc coating thickness. This represented about 10 percent of the total coating thickness. The throat was in good condition and there was no leakage through the valve when leak-tested at 55 psig. A later inspection after approximately 8000 hours in slurry service showed no further erosion of either the polyethylenecoated disc or the valve body liner. All wetted surfaces were coated with a thin scale. This valve is considered to be in excellent condition except for four small irregular wear patterns at the disk edge probably caused by debris trapped at the sealing edge during closure. The valve body liner of abrasion-resistant polyethylene is in excellent condition. Measurements of the disk thickness show no change or loss of the coating material. The valve service is primarily in the open position.

The knife gate valves tested at Shawnee are Type 316 stainless steel Fabri-Valves. There are a total of eight such valves in service: four on the Hayward strainers on the TCA recirculating slurry pump (G-201) discharge and the remainder on the Hayward strainers on the spray tower recirculating slurry pump (G-204) discharge. Inspections were confined mainly to the four, 6-inch

All four valves could be operated by the hand wheel after application of grease onto the stems and into the knife gate slots. Observations specific to each valve were:

- The valve on the downstream side of the north Hayward strainer had very slight rounding of the knife gate at the 6 o'clock position, slight erosion of the valve body on the downstream edge at the 11 o'clock position, and small amounts of scale on the downstream face of the knife gate.
- The valve on the upstream side of the north Hayward strainer had no bodily erosion and only slight rounding of the knife gate at the 6 o'clock position. Thin, smooth scale was found on the suction side. This valve had a guide piece instead of a backup half-ring provided in the other valves.
- The valve on the downstream side of the south Hayward strainer had no bodily erosion and only slight rounding of the sharp edge of the gate. The backup ring had a couple of weld spots that had smoothed off.
- The valve on the upstream side of the south Hayward strainer had no noticeable erosion. White, hard 10 mil-thick scale was on the upstream face.

The exterior bodies of all four valves appeared to be in good condition. Operation of these valves without O rings had sometimes resulted in slight leakage past the gate when the basket was being emptied, but this was not a very serious problem. The deposition of hard scale on the gate was perhaps the major factor that made the valve hard to operate and was the major contributor to the failure of the O-rings.

13.8.4 Strainers

Dual-basket in-line Elliott strainers were originally installed at the discharge of the TCA and spray tower recirculating slurry pumps to alleviate the problem of slurry nozzles plugging with debris and other foreign materials. During the May 1975 boiler outage each Elliott strainer was replaced by two single-basket in-line Hayward Strainers mounted in parallel at the discharge of each pump. The replacement of the Elliott strainers became necessary because of the serious erosion that developed in the outlet necks. For the Elliott strainer on the TCA pump discharge, erosion was also observed on edges where the slide gate sealed each basket chamber. Inspection after approximately 3700 hours of service revealed that the iron body of the Elliot strainer was severely eroded in several areas. The 316 stainless steel baskets (30-mil thick with 3/8-inch-diameter perforations) had not eroded significantly. Results of inspections of the 6-inch single-basket Hayward strainers on the spray tower pump discharge after approximately 8000 hours of service were:

- Erosion at several locations on the basket support ledge. At two of the locations, where severe erosion had occurred, about 80 percent of the ledge had disappeared.
- Severe gouging, as much as 1/4 inch deep, of the discharge throat was observed at two locations.
- Minor erosion along the inlet flange face, lower half portion of Unit A.
- A triangular-shaped erosion spot 6 mm deep in the discharge throat of Unit A.
- Grooves up to 13 mm deep in the outlet throat of Unit B.
- Two erosion areas in the basket support flange.
- Basket of both units were in good condition.

For the two 8-inch single-basket Hayward strainers on the TCA pump discharge, inspection after approximately 10,600 hours of service revealed:

- A small erosion spot about 20 mm long at the bottom of the discharge throat of one of the strainers.
- Some erosion of the basket support ledge of both strainers. This erosion was not very extensive.
- Baskets of both units were in good condition.

Currently both types of strainers are in service. Neither type has shown to be particularly better than the other.

Section 14

FLUE GAS CHARACTERIZATION FOR PARTICULATE AND SULFUR TRIOXIDE EMISSIONS

A series of tests were conducted on the TCA and venturi/spray tower systems to determine the effect of the major operating variables on particulate mass removal efficiency and size distribution, and on sulfuric acid vapor (SO_3) emissions. Additionally, the effect of slurry entrainment on scrubber particulate emissions was estimated.

During the testing, the scrubber systems were supplied with flue gas from Boiler No. 10 of the Shawnee Steam Plant, either directly from the boiler (high fly ash loading) or after the electrostatic precipitator (low fly ash loading). The flue gas inlet mass loading usually ranged from 3 to 6 grains/dry scf (gr/dscf) at high fly ash loading, and from 0.04 to 0.20 gr/dscf at low fly ash loading. More detailed information on the test results can be found in References 4, 5, and 24.

14.1 PARTICULATE MASS REMOVAL EFFICIENCY

Particulate mass loading values were determined using a modification of EPA Method Five. A Hi-Volume sampling train manufactured by the Acurex Corporation was used.

For both the TCA and venturi/spray tower systems, overall efficiency increased with increasing pressure drop and decreased with increasing gas flow rate (gas velocity). Also, outlet mass loadings were higher with a continuous mist eliminator bottom wash using diluted clarified liquor, as compared to an intermittent bottom wash with fresh water.

14.1.1 TCA System

At high fly ash loading, the TCA had mass removal efficiencies greater than 98 percent. Outlet mass loading averaged about 0.046 gr/dscf at a pressure drop of 9 inches H_2O. The 1971 EPA New Source Performance Standard (NSPS) for particulate emission of 0.10 lb/10^6 Btu corresponds to an outlet loading of approximately 0.052 gr/dscf, assuming 30 percent excess air in the flue gas. For pressure drops in excess of 7 inches H_2O, the outlet loadings from the TCA were generally below the level set by the 1971 NSPS.

At low fly ash loading, the TCA had removal efficiencies from 50 to 86 percent. Typical outlet mass loadings ranged from 0.018 to 0.032 gr/dscf, which are well below the level specified by the 1971 NSPS.

However, the performance of the TCA at both high and low fly ash loading did not meet the NSPS of 0.03 lb/10^6 Btu (corresponding to approximately 0.016 gr/dscf) as revised in June 1979.

14.1.2 Venturi/Spray Tower System

At high fly ash loading, the venturi/spray tower system had removal efficiencies greater than 99 percent. Outlet mass loading averaged about 0.042 gr/dscf for a total pressure drop of 16 inches H_2O, which is below the 1971 NSPS but above the revised 1979 NSPS.

With low fly ash loading, the venturi/spray tower system had removal efficiencies from 80 to 99 percent. Typical outlet loadings ranged from 0.003 to 0.023 gr/dscf, which were well below the 1971 NSPS but met the revised 1979 NSPS only about half of the time.

14.2 PARTICULATE SIZE DISTRIBUTION

Particulate size distributions were measured with heated inertial impactors located outside of the stack. A Brinks Model BMS-11 impactor was used for inlet sampling and a Meteorology Research, Inc. (MRI) Model 1502 impactor was used for outlet sampling.

14.2.1 TCA System

Mass removal efficiency on the TCA for flue gas with high fly ash loading varied from about 10 to 60 percent for 0.1 micron particles to greater than 98 percent for particles larger than 5 microns. For the low fly ash loading tests, removal efficiency was between 30 and 75 percent for 0.1 micron particles and about 90 percent for particles larger than 5 microns.

For the high fly ash loading tests, emission of particles less than 2 microns in diameter averaged 0.025 gr/dscf, except for a low gas rate run and a low slurry rate run where the average was higher at 0.037 gr/dscf. This decreased removal efficiency would be expected with slurry or gas turndown in a TCA because of decreased sphere activity in the beds. Emission of particulates with diameters greater than 2 microns averaged 0.028 gr/dscf, except for a run with a continuous mist eliminator bottom wash and a run with MgO addition where the emissions averaged 0.055 and 0.038 gr/dscf, respectively. Emissions during a low fly ash loading run averaged 0.003 gr/dscf for particles with diameters less than 2 microns and 0.025 gr/dscf for particles with diameters greater than 2 microns.

14.2.2 Venturi/Spray Tower System

Mass removal efficiency of the venturi/spray tower system for the flue gas with high fly ash loading varied from 50 to 80 percent for 0.1 micron particles to greater than 99 percent for particles larger than 5 microns. For the tests with low fly ash loading, removal efficiency was the same for 0.1 micron particles but decreased to approximately 95 percent for particles larger than 5 microns. Within the ranges tested, the removal efficiency appeared to be fairly independent of the levels of the independent variables, such as gas rate, slurry rate, and pressure drop.

Mass emission of particles less than 2 microns diameter averaged 0.016 gr/dscf for the high fly ash loading tests. Emission of particles greater than 2 microns averaged 0.006 gr/dscf for all tests except for a test with MgO addition and a test where the venturi was operated at minimum pressure drop. The data for these runs was not of sufficient quality to estimate a mass emission for the greater than 2 micron diameter particulate. For a low fly ash loading test, emissions for particles less than 2 microns in diameter averaged 0.002 gr/dscf while emissions for particles greater than 2 microns in diameter averaged 0.003 gr/dscf.

14.3 SLURRY ENTRAINMENT

Non-dispersive infrared and thermo-gravimetric analysis of the particulate on a single outlet filter from a TCA test with low fly ash loading indicated that emissions from entrained scrubber reaction products were in the range of 0.005 gr/dscf. This compares to an emission level in the range of 0.025 gr/dscf for particles greater than 2 microns (or a total emission of 0.028 gr/dscf for all size particles). Additionally, results from air/slurry entrainment tests on the TCA (Section 11.4.2) indicated a slurry (40 percent fly ash and 60 percent reaction products) entrainment value between 0.001 and 0.005 gr/dscf. These results would indicate that less than 20 percent of the particulate emissions from the scrubber systems are entrained reaction products.

Scanning Electron Micrographs (SEM) were taken of the scrubber outlet particulate captured on the impactor third stage (7.8 to 9.3 microns cut size) and sixth stage (1.1 to 1.2 micron cut size) during a venturi/spray tower test. Very little emitted reaction products were visible on the sixth stage (the deposits appeared to be all spherical fly ash) while crystals of $CaSO_3 \cdot 1/2H_2O$ (rosettes) were visible on stage three. These SEM photographs suggest that the emitted scrubber slurry reaction products are concentrated in the larger particle size fractions, i.e., greater than 2 microns.

Other testing has also indicated that the emitted reaction products are concentrated in the larger size fractions. For example, continuous diluted clarified liquor mist eliminator underwash in the TCA significantly increased emissions only in the greater than 2 micron fraction range. Also, addition of MgO to the scrubber liquor, which increases total dissolved solids, resulted in an increase in emissions for the larger particle size fractions.

14.4 SULFURIC ACID VAPOR (SO_3)

The vapor phase concentrations of sulfuric acid (SO_3) were measured using a controlled condensation technique. SO_3 measurements on the TCA and venturi/spray tower systems indicated that the percent SO_3 removal was independent of the levels of the operating variables (e.g., pressure drop) and inlet SO_3 concentration.

For the TCA system SO_3 emission concentrations ranged from zero to 16 ppm with average removal ranging from 18 to 88 percent. For the venturi/spray tower system, SO_3 emission concentrations ranged from zero to 14 ppm with average removal ranging from 50 to 75 percent. The fact that the outlet SO_3 concentrations were always below the inlet concentrations indicated that the scrubbing process did not contribute to SO_3 emissions.

Section 15

WASTE SOLIDS DEWATERING AND HANDLING CHARACTERISTICS

At Shawnee the primary dewatering of the scrubber slurry occurs in the clarifiers. Further dewatering of the clarifier underflow is usually accomplished in the venturi/spray tower system by a rotary drum vacuum filter and in the TCA system by a centrifuge. With these two pieces of dewatering equipment in series with clarifiers, a very tight liquor loop closure can be achieved.

15.1 CLARIFIERS

The clarifiers are conventional Dorr-Oliver solids contact units. Each has a heavy duty rake and scraper mechanism supported from a bridge. The rake and scraper have an automatic torque control lift mechanism. The venturi/spray tower has a 20-foot diameter unit and the TCA has a 30-foot unit.

The clarifiers are operated primarily for their clarification capacity rather than for their maximum thickening ability. In general, the underflow solids concentrations are maintained between 30 and 35 weight percent when operated with the filter or centrifuge downstream and between 35 and 40 weight percent when operated alone. When operating with underflow solids concentrations in this range, there have been few problems with plugging of the underflow line. To avoid plugging when the scrubbers are down, the clarifiers are put on total recycle, meaning that the underflow is routed back to the clarifier inlet.

Early in the Advanced Test Program there were problems with unsatisfactory clarity in the TCA overflow. The problem was corrected by extending the feed well from 2 feet to 8 feet deep to provide a longer liquid up-flow residence time and to minimize short-circuiting.

15.2 FILTER

An Ametek 3 ft x 6 ft rotary drum vacuum filter without cake wash is operated at the facility for waste sludge dewatering and dissolved scrubbing additive recovery. Cake discharge is achieved by a snap-blowback air cycle.

The feed to the filter (from clarifiers underflow) is typically 15 gpm with 30 to 35 weight percent solids content. The filtrate generally contains less than 0.02 weight percent solids. The filter cake varies from 55 to 85 weight percent solids, depending mainly on whether the sludge is unoxidized or oxidized (see Section 15.4).

Filter cloth life has been a major problem. Cloth life varies between 130 hours and 2100 hours. The major causes of failure are cloth blinding and fraying. Although the reasons for these failures have not always been clear, operating experience indicated a relationship between cloth life and the technique by which the cloth is fitted to the drum. A carefully controlled amount of looseness in the fit between the dividers appeared to be desirable for cake discharge and non-blinding. The looseness evidently allows the cloth to "snap" the cake off when the air puff during the cake discharge cycle is applied to the given filter cloth section. Two additional observations are that (1) oxidized sludge exhibited less tendency towards cloth blinding and (2) the Ametek olefin cloth appears to provide the most satisfactory service of those cloths tested. The reason for the better service life of Ametek cloth is attributed to the looseness of weave. Results from air permeability tests showed a correlation between higher initial air permeability and longer cloth life. (Cloth permeability is a function of the looseness of the weave.)

15.3 CENTRIFUGE

An 18 x 28 inch solid bowl continuous centrifuge manufactured by the Bird Machine Co. is used to dewater scrubber waste sludge from the clarifier underflow in the TCA system. Typical operating conditions consist of a feed stream flow of 15 gpm at 30 to 35 weight percent solids, a centrate of 0.1 to 3.0 weight percent solids, and a cake of 55 to 65 weight percent solids for unoxidized slurry. A cake of 70 to 80 weight percent solids is typical for oxidized slurry.

The abrasiveness of the feed slurry tends to wear certain components of the centrifuge. As the centrifuge wear increases there is a gradual and continued increase of centrate suspended solids. Inspection of the centrifuge over the course of the Advanced Test Period indicates that various components have worn. These include conveyor tips (especially on the discharge end and at the junction of the cylinder and the 10 degree section of the conveyor), the cake plows, casing head plows, and the solids discharge head near the discharge ports. The hard facing materials on the centrifuge consist of Stellite 1016 on the blade tips of the conveyor and Colmonoy #6 on the pushing faces of the conveyor. Table 15-1 summarizes the centrifuge operation, wear, and repair.

Except for the gradual wear of the centrifuge parts and the resulting gradual deterioration of the centrate clarity, the centrifuge has operated satisfactorily (consistent solids content in the cake, with no plugging).

15.4 EFFECTS OF OPERATING CONDITIONS ON DEWATERING

The ability of the filter and centrifuge to dewater the scrubber slurry is significantly affected by the degree of sulfite oxidation. Natural oxidation of sulfite to sulfate in the scrubber system amounts to only 10 to 30 percent, and calcium sulfite is the predominant material in the waste sludge. Forced oxidation normally yields greater than 90 percent sulfite oxidation and calcium sulfate is the predominant material in the waste sludge.

The primary purpose for oxidizing the scrubber solids is to improve waste solids dewatering and disposal characteristics because, compared to sulfite sludge, gypsum sludge is much easier to dewater, settles faster, and is non-thixotropic. Dewatering characteristics of waste solids are routinely monitored at the Shawnee Test Facility by cylinder settling tests and vacuum funnel filtration tests (Buchner funnel tests).

Cylinder settling tests are performed in a 1000 ml cylinder containing a rake which rotates at 0.17 rpm. The initial settling rate and ultimate settled solids concentration are recorded as indices of dewatering characteristics.

Table 15-1

SUMMARY OF CENTRIFUGE OPERATION, WEAR, AND REPAIR

Hours on stream since last servicing	Wear sites revealed by inspection	Repair made
1400	Conveyor blades worn off	Reapplication of hard facing materials: Stellite 1016 Colmonoy #6
4750	Cake plows worn in outboard area Solids weir worn Conveyor worn Forward feed compartment discharge ports eroded	Rotating unit sent to factory for repair
4000	Wear at center feed ports Wear on plows at solids discharge ends Conveyor blades worn	Limited hardface welding performed onsite
6460	Serious wear on conveyor tips, especially discharge end and at junction of cylinder and 10° section Wear at casing head plows Wear at solids discharge head	Major overhaul at factory Gear and bearing serviced Rebuilt all worn conveyor surfaces and discharge ports Added tungsten carbide hardfacing to conveyor tips Replaced all seals, bushings, case plows and discharge ports as necessary

The initial settling rate is a qualitative index of the solids settling properties only. Design rates for sizing clarifiers have to take into consideration the hindered settling rate as the solids concentrate. The ultimate settled solids from the cylinder tests represents the highest achievable solids concentration in a settling pond.

Funnel filter tests are performed in a Buchner funnel with Whatman No. 2 filter paper under a vacuum of 25 in. Hg. The funnel test results correlate well with the Shawnee rotary drum vacuum filter results when the filter cloth is not blinded. However, the funnel test cakes tend to have lower solids concentrations.

Table 15-2 presents a summary of average values and ranges of all the cylinder settling and funnel filtration test data gathered. It shows the effect of oxidation, fly ash loading, and additive concentration on initial settling rate, ultimate settled solids, and funnel test cake solids.

The benefit of forced oxidation on the settling and dewatering characteristics of the sludge are clearly evident. Looking first at runs without magnesium addition, the initial settling rate for an oxidized slurry (0.9 - 1.2 cm/min average range) was much higher than unoxidized slurry (0.2 - 0.4 cm/min average range), regardless of whether it was with high or low fly ash loading. With forced oxidation, the high settling rates were not dependent on the oxidation scheme (one or two scrubber loop mode). Again excluding magnesium runs, the average ultimate settled solids and funnel test solids were all between 70 and 76 weight percent for the oxidized slurry, whereas for unoxidized slurry the ultimate settled solids and funnel test solids were between 40 and 57 weight percent.

Table 15-2

SUMMARY OF DEWATERING CHARACTERISTICS ON SHAWNEE SYSTEM BLEED

Oxidation	Fly Ash Loading	Alkali	Oxidation Mode	Initial Settling Rate, cm/min		Ultimate Settling Solids, wt%		Funnel Test Cake Solids, wt%		Slurry Solids	Effective Mg^{++} Concentration, ppm
				Avg.	Range	Avg.	Range	Avg.	Range		
Yes	High	LS	1-loop	1.1	0.6-1.3	74	67-84	76	73-80	15	0
Yes	High	LS	2-loop	1.2	1.0-1.4 (1)	72	62-86	72	65-88	15	0
Yes	High	LS	Bleed Stream	0.4	0.3-0.6	71	61-84	73	71-76	15	5000
Yes	High	LS	2-loop	0.8	0.2-1.2	66	46-73	70	46-76	15	8000
Yes	High	L	2-loop	1.0	0.8-1.2	73	61-85	71	64-78	15	0
Yes	Low	LS	2-loop	0.9	0.6-1.2	74	61-87	73	64-82	15	0
Yes	Low	L	2-loop	1.2	0.4-2.4	70	60-81	76	64-83	15	0
No	High	LS	-	0.2	0.1-0.5	54	41-67	57	48-66	15	0
No	High	LS	-	0.2	0.1-0.4	45	30-60	57	45-64	15	5000
No	High	LS	-	0.1	0.0-0.1	41	32-46	55	47-69	15	9000
No	High	L	-	0.2	0.2-0.5	50	48-66	53	51-55	15	0
No	High	L	-	0.8	0.2-1.2	42	31-52	52	43-63	8	2000
No	Low	LS	-	0.2	0.1-0.5	43	33-54	50	41-59	15	0
No	Low	L	-	0.4	0.1-0.9	40	30-55	45	40-50	8	0

Note: Values for forced oxidation runs are only from data where solids oxidation is greater than or equal to 90 percent.

(1) Oxidizer pH = 5.0. At pH 4.5 the average initial settling rate was 1.1, with a range of 0.6-0.9. At pH 5.5, the average initial settling rate was 1.1, with a range of 0.8-1.5.

The initial settling rate of unoxidized slurry was probably limited by the sulfite particles. In the case of oxidized slurry, the rate was probably limited by the fly ash. Even in the case of slurry with low fly ash loading, fly ash constituted about one weight percent of the solids.

The addition of magnesium primarily affected the initial settling rate. For oxidized slurry with the 2-loop oxidation mode and with 8000 ppm effective magnesium ion concentration, the average initial settling rate, the ultimate settled solids, and the funnel test cake solids were all slightly lower than those for oxidized slurry without magnesium. The initial settling rate for bleed stream slurry was about half that of other oxidized slurries. The ultimate settled solids and funnel test cake solids were in the same range as those with other oxidized slurries.

The effect of magnesium was more pronounced for unoxidized slurry. For a limestone slurry with high fly ash loading, the average initial settling rate was 0.20 cm/min with no magnesium and 0.05 cm/min with 9000 ppm effective magnesium. Thus, the addition of magnesium decreased the settling rate by a factor of four. The ultimate settled solids were also somewhat lower for slurries with magnesium. The funnel test cake solids were about the same.

In the presence of magnesium, the initial settling rate (but not the ultimate settled solids) was affected due to the increase in liquor viscosity and density (resulting from increased total dissolved solids).

On the rotary drum vacuum filter, cake solids concentration is always above 80 percent with oxidized slurry. This is true regardless of whether additives are present or not. As would be expected, the filter performance is not affected by the reduction in initial settling rate. Unoxidized cake from the drum filter averages about 50 to 65 weight percent solids. The unoxidized solids tend to be thixotropic, like quicksand, while the oxidized solids are more like moist soil.

On the centrifuge, cake solids concentration ranged from 65 to 75 weight percent with oxidized slurry and ranged from 55 to 65 weight percent solids with unoxidized slurry.

Generally, there is a significant reduction in the quality of slurry settling and dewatering characteristics when the oxidation drops below about 90 percent although the data are sparse for some of the test blocks.

The data thus far generated clearly illustrate the benefits of forced oxidation with respect to increased initial solids settling rate, ultimate settled solids, and funnel test cake solids, as well as the performance of the dewatering equipment.

Section 16

ANALYTICAL REQUIREMENTS

To control system parameters and to develop advanced theoretical models by which lime/limestone SO_2 scrubbing systems may be described, routine analyses of scrubber slurry streams are performed. The test facility has a fully staffed and equipped laboratory capable of performing all the required analyses. The type and frequency of these analyses are listed in Table 16-1. A complete description of the analytical procedures used for these analyses can be found in Reference 6.

16.1 GENERAL TEST SCHEDULE

Presented in Table 16-1 is a list of the location and frequency of samples taken and the type of analysis performed on each sample. Basically, the scrubber inlet slurry streams are analyzed for all components every 8 hours. Variables essential to scrubber operation and control are determined more frequently; pH is read every 2 hours, percent solids in the recirculating slurry is determined every 4 hours, and any additive whose concentration is to be controlled is determined every 2 hours.

Scrubber outlet streams are analyzed once every 8 hours for the liquor phase only. This is done to gather data for scrubber characterization. Percent

Table 16-1

TYPE AND FREQUENCY OF SAMPLE ANALYSES

Sample Location	Type of Analysis	Frequency of Sampling
Venturi Inlet Spray Tower Inlet TCA Inlet	Complete solids and liquor analysis	Every 8 hours
	Weight percent solids of slurry	Every 4 hours
	pH of slurry	Every 2 hours
	Additive (if any)	Every 2 hours
	Mn or Fe (venturi and spray tower inlet only)	Every 8 hours
Venturi Outlet Spray Tower Outlet TCA Outlet	Complete liquor analysis Mn or Fe (TCA outlet only)	Every 8 hours
Alkali Feed	Weight % solids	Every 2 hours
Clarifier Underflow	Weight % solids	Every 4 hours
Filter	Weight % solids in filtrate	Every 4 hours
	Weight % solids in filter cake	Every 4 hours
Centrifuge	Weight % solids in centrate	Every 4 hours
	Weight % solids in centrifuge cake	Every 4 hours
Special Tests	Buchner Funnel filtration test	Every 24 hours
	Cylinder settling test	Every 24 hours

solids in alkali feed, a controlled input, are determined every 2 hours. Thickener underflow percent solids concentration is determined every 4 hours. The percent solids in the filter and centrifuge cakes is determined every 4 hours to document the dewatering equipment performance and to facilitate material balance calculations.

Special tests are also performed by laboratory personnel. These include a Buchner Funnel filtration test and a cylinder settling test once a day to characterize the slurry solids dewatering properties. The laboratory also conducts special analyses, as needed, on samples such as scrubber scale and solids deposits, recheck samples, etc.

16.2 LABORATORY STAFFING

A 24-hour day is divided into three 8-hour shifts. Each shift has a basic staff of two laboratory technicians, and a shift supervisor who performs more complicated analytical tests. During the day shift, there are three additional persons: a support chemist who is responsible for developing procedures for special tests as well as providing samples for quality assurance tests, the laboratory supervisor, and a third laboratory technician who performs special tests as required.

16.3 QUALITY ASSURANCE

The primary method for ensuring reliability of analytical data is the daily evaluation of analytical results by the onsite staff and by Bechtel personnel in San Francisco. Ionic imbalance and the general reasonableness of results are used as the measure of acceptability. During the Advanced Test Program, solids analyses with an ionic imbalance greater than ± 8.5 percent and liquor analyses with an ionic imbalance greater than ± 15 percent (± 20 percent prior to August 18, 1976) were rejected. The solids ionic imbalance limit of ± 8.5 percent was based on the results of about 300 solids analyses performed prior to December 12, 1975. In these analyses, the average ionic imbalance was ± 3.5 percent, with a standard deviation of 2.5 percent. Thus, ± 8.5 percent ionic imbalance included approximately 95 percent of the solids analysis results. The liquor ionic imbalance values for 60 analyses performed in July 1976 had an average of ± 6.4 percent and a standard deviation of 4.4 percent. Thus, ± 15 percent ionic imbalance included 95 percent of the liquor analysis results.

The results of the analysis of liquor and solids standards were used to monitor both the accuracy (closeness between the true and the experimentally determined values) and the precision (reproducibility) of analytical results. In addition, a TVA program for interlaboratory comparison of analytical results was initiated. Selected quality assurance samples were routinely sent to the TVA General Analytical Laboratory in Muscle Shoals, Alabama, after their analysis at the Shawnee Test Facility laboratory.

Section 17

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APPENDIX A

CONVERTING UNITS OF MEASURE

CONVERTING UNITS OF MEASURE

Environmental Protection Agency policy is to express all measurements in Agency documents in metric units. In this report, however, to avoid undue costs or lack of clarity, English units are used throughout. Conversion factors from English to metric units are given below:

To Convert From	To	Multiply By
scfm (60°F)	nm^3/hr (0°C)	1.61
cfm	m^3/hr	1.70
°F	°C	(°F-32)/1.8
ft	m	0.305
ft/hr	m/hr	0.305
ft/sec	m/sec	0.305
ft^2	m^2	0.0929
ft^2/tons per day	m^2/metric tons per day	0.102
gal/mcf	l/m^3	0.134
gpm	l/min	3.79
gpm/ft^2	$l/min/m^2$	40.8
gr/scf	gm/m^3	2.29
in.	cm	2.54
in. H_2O	mm Hg	1.87
lb	gm	454
lb-moles	gm-moles	454
lb-moles/hr	gm-moles/min	7.56
lb-moles/hr ft^2	gm-moles/min/m^2	81.4
lb-moles/min	gm-moles/sec	7.56
psia	kilopascal	6.895

APPENDIX B

DATABASE SUMMARY

DATABASE SUMMARY

The NOMAD database system can be used to print reports of selected data. The run summary table reports for the period October 1974 through June 1978 are presented in this appendix.

The following codes and abbreviations are used in describing the operating conditions and the system configuration:

- Alkali type
  - L = lime
  - LS = limestone
- Fly ash and MgO addition
  - Y = yes
  - N = no
- Spray tower header configuration
  - 1 = lowest spray bank
  - 2 = second lowest
  - 3 = second highest
  - 4 = highest
- Mist eliminator system configuration
  - 1-3P/OV = one three-pass, open-vane mist eliminator
  - 2-3P/CV = two three-pass, closed-vane mist eliminator
- Mist eliminator wash, bottom/top
  - C = continuous
  - I = intermittent
  - S = sequential
- Dewatering system
  - CL = clarifier
  - CE = centrifuge
  - F = filter
  - LAM = Lamella inclined plate settler
  - e.g., CL/CE = clarifier and centrifuge in series

- Alkali addition point
  DNC = downcomer
  EHT = effluent hold tank

- TCA total bed height is given in inches for 3 beds

- TCA sphere type
  FOAM = 1 5/8-inch solid nitrile foam spheres
  TPR = 1 1/2-inch hollow thermoplastic rubber spheres

The analytical point designations for slurries are as follows:

1805 = venturi/spray tower bleed stream oxidation tank
1815 = venturi inlet
1816 = spray tower inlet
1825 = spray tower outlet
1851 = venturi outlet
2816 = TCA inlet
2825 = TCA outlet
2831 = inlet to Penberthy air eductor
2832 = TCA oxidation tank (first of two series tanks)

VST RUN DEFINITION

RUN NO.	RUN REP FLAG	START DATE	START TIME	END DATE	END TIME	HOURS ON STRM	FACT OR TIME	RUN COMMENTS
VFG-1A	N/A	10/10/76	1550	10/18/76	0530	182	T	N/A
VFG-1B	N/A	10/20/76	1734	10/29/76	0830	207	T	N/A
VFG-1C	N/A	10/29/76	1330	11/02/76	2215	87	T	N/A
VFG-1D	N/A	11/02/76	2215	11/06/76	2215	96	T	N/A
VFG-1E	N/A	11/06/76	2215	11/10/76	2200	96	T	N/A
VFG-1F	N/A	11/10/76	2200	11/18/76	0815	124	T	N/A
VFG-1G	N/A	11/18/76	1600	11/21/76	1518	71	T	N/A
VFG-1I	N/A	11/22/76	1530	11/27/76	1300	117	T	N/A
VFG-1P	N/A	11/27/76	1305	12/04/76	0715	157	T	N/A
VFG-1Q	N/A	//	N/A	//	N/A	N/A	N/A	N/A
601-1A	N/A	10/09/73	1420	11/17/73	2300	666	T	N/A
601-1B	N/A	11/17/73	2300	12/15/73	2300	912	T	N/A
601-1C	N/A	12/15/73	2300	01/08/74	2200	575	T	N/A
602-1A	N/A	03/15/74	2000	04/01/74	0500	393	T	STEADY STATE NOT ACHIEVED
603-1A	N/A	04/02/74	1200	04/19/74	0800	395	T	N/A
604-1A	N/A	04/26/74	1300	07/15/74	0100	1828	T	N/A
605-1A	N/A	07/31/74	0800	08/06/74	0800	141	T	N/A
606-1A	N/A	08/07/74	0500	08/14/74	1600	170	T	N/A
607-1A	N/A	08/15/74	2000	08/20/74	0800	108	T	N/A
608-1A	N/A	08/21/74	1300	09/17/74	0800	610	T	N/A
609-1A	N/A	09/20/74	1800	10/02/74	0700	277	T	N/A
610-1A	N/A	10/02/74	1600	10/13/74	0700	253	T	N/A
611-1A	N/A	10/25/74	1500	11/11/74	1100	392	T	N/A
612-1A	N/A	11/13/74	1900	11/14/74	1040	16	T	N/A
613-1A	N/A	11/14/74	1040	11/14/74	2010	10	T	N/A
614-1A	N/A	11/15/74	0300	11/15/74	1200	9	T	N/A
614-1B	N/A	11/16/74	1500	11/18/74	0745	41	T	N/A
615-1A	A	11/15/74	1200	11/15/74	2015	8	T	N/A
615-1B	A	11/16/74	0500	11/16/74	1500	10	T	N/A
616-1A	N/A	11/15/74	2100	11/16/74	0500	8	T	N/A
617-1A	N/A	11/14/74	2010	11/14/74	2320	3	T	N/A
618-1A	N/A	11/21/74	1900	12/02/74	0700	235	T	N/A
619-1A	N/A	12/19/74	1800	01/02/75	1300	327	T	N/A
620-1A	N/A	01/10/74	1245	01/17/74	0745	163	T	N/A
621-1A	N/A	01/18/75	1500	01/23/75	0800	113	T	N/A
622-1A	N/A	01/30/75	1900	03/05/75	0800	787	T	N/A
623-1A	N/A	03/12/75	1400	03/19/75	0900	162	T	N/A
624-1A	N/A	03/19/75	1300	04/23/75	0900	823	T	N/A
625-1A	N/A	06/20/75	1900	07/09/75	0900	319	T	N/A
626-1A	N/A	07/09/75	1400	08/04/75	0800	569	T	N/A
627-1A	N/A	08/05/75	1300	08/13/75	1100	187	T	N/A
628-1A	N/A	08/16/75	1100	09/18/75	0800	717	T	N/A
628-1B	N/A	09/18/75	1300	10/07/75	0800	426	T	N/A
629-1A	N/A	04/28/76	1800	05/12/76	0800	266	T	N/A

VST RUN DEFINITION

RUN NO.	RUN REP FLAG	START DATE	START TIME	END DATE	END TIME	HOURS ON STRM	FACT OR TIME	RUN COMMENTS
630-1A	N/A	05/12/76	1000	05/18/76	0800	142	T	N/A
631-1A	N/A	05/18/76	1145	05/24/76	1345	145	T	N/A
632-1A	N/A	05/28/76	1815	06/04/76	0245	151	T	N/A
633-1A	N/A	06/05/76	1000	06/14/76	0530	212	T	N/A
634-1A	N/A	06/19/76	1700	07/02/76	2345	319	T	N/A
635-1A	N/A	07/16/76	1710	07/26/76	0813	190	T	N/A
636-1A	N/A	07/28/76	1830	08/04/76	1256	164	T	N/A
637-1A	N/A	08/06/76	1315	08/12/76	0735	137	T	N/A
638-1A	N/A	08/17/76	1726	08/24/76	0547	174	T	N/A
639-1A	N/A	08/24/76	1455	09/01/76	0550	183	T	N/A
640-1A	N/A	09/02/76	1555	09/09/76	0515	157	T	N/A
641-1A	N/A	09/09/76	1430	09/14/76	1656	120	T	N/A
642-1A	N/A	09/15/76	1430	09/27/76	0525	249	T	N/A
643-1A	N/A	09/27/76	1250	10/05/76	1203	191	T	N/A
701-1A	N/A	10/09/75	1800	10/12/75	1900	73	T	N/A
702-1A	N/A	10/14/75	1700	10/17/75	2000	60	T	N/A
703-1A	N/A	10/19/75	0900	11/01/75	2200	319	T	N/A
704-1A	N/A	11/03/75	2000	11/06/75	1300	66	T	N/A
705-1A	N/A	11/07/75	1600	11/13/75	0800	136	T	N/A
706-1A	N/A	11/13/75	1900	11/21/75	0700	180	T	N/A
707-1A	N/A	11/21/75	1600	11/26/75	1300	118	T	N/A
708-1A	N/A	11/26/75	1400	12/02/75	0700	138	T	N/A
709-1A	N/A	12/06/75	1700	12/12/75	0700	134	T	N/A
710-1A	N/A	12/12/75	1400	12/22/75	0700	234	T	N/A
711-1A	N/A	12/24/75	1300	12/30/75	1200	144	T	N/A
711-1B	N/A	12/30/75	1200	01/02/76	1100	71	T	N/A
712-1A	N/A	01/02/76	1200	01/07/76	1100	119	T	N/A
712-1B	N/A	01/07/76	1500	01/08/76	0800	18	T	THIS IS AN ABSORBENT DEPLETION RUN
713-1A	N/A	01/08/76	0900	01/10/76	1200	52	T	N/A
714-1A	N/A	01/19/76	1600	01/26/76	0700	157	T	N/A
715-1A	N/A	01/26/76	1800	01/27/76	1700	23	T	N/A
716-1A	N/A	01/27/76	1700	01/28/76	1000	18	T	PH DROPPED DRASTICALLY
717-1A	N/A	01/28/76	1400	02/05/76	0800	181	T	N/A
718-1A	N/A	07/03/76	1530	07/15/76	1000	235	T	N/A
801-1A	N/A	01/04/77	1420	01/15/77	1255	263	T	N/A
801-2A	N/A	//	N/A	//	N/A	N/A	N/A	N/A
802-1A	N/A	01/24/77	1550	02/04/77	0805	256	T	N/A
803-1A	N/A	02/04/77	1400	02/10/77	0730	138	T	N/A
804-1A	Q	02/10/77	1210	02/18/77	0205	151	T	N/A
805-1A	N/A	02/18/77	1620	02/23/77	0800	112	T	N/A
806-1A	N/A	02/23/77	1440	02/25/77	1130	45	T	N/A
806-1B	N/A	02/25/77	1130	02/27/77	0815	45	T	N/A
806-1C	N/A	02/27/77	0815	03/01/77	1415	54	T	N/A
806-1D	N/A	03/01/77	1500	03/03/77	0800	41	T	N/A

VST RUN DEFINITION

RUN NO.	RUN REP FLAG	START DATE	START TIME	END DATE	END TIME	HOURS ON STRM	FACT OR TIME	RUN COMMENTS
807-1A	N/A	03/03/77	1630	03/06/77	1015	66	T	N/A
808-1A	N/A	03/06/77	1015	03/09/77	0330	65	T	N/A
809-1A	N/A	08/12/77	1510	08/18/77	0820	137	T	N/A
810-1A	N/A	08/18/77	1355	08/25/77	0735	162	T	N/A
811-1A	N/A	08/25/77	1245	09/02/77	0410	184	T	N/A
812-1A	N/A	09/02/77	1108	09/08/77	0752	141	T	N/A
813-1A	N/A	//	N/A	//	N/A	N/A	N/A	N/A
814-1A	N/A	09/08/77	1620	09/15/77	0746	136	T	N/A
815-1A	N/A	09/15/77	1320	09/28/77	0730	306	T	SOLIDS SAMPLES ARE BEING RUN BY WET METHOD BEGINNING 0730 ON 9-16-77
816-1A	N/A	09/28/77	1005	10/04/77	0820	142	T	N/A
817-1A	N/A	10/18/77	1110	10/26/77	0727	188	T	N/A
818-1A	N/A	10/26/77	1155	11/01/77	0735	141	T	N/A
819-1A	N/A	11/01/77	1655	12/08/77	0850	840	T	N/A
819-1B	N/A	12/08/77	1032	12/15/77	0739	126	T	N/A
820-1A	N/A	03/01/78	2030	04/04/78	0800	462	T	N/A
820-1B	N/A	04/04/78	1230	04/10/78	0505	137	T	N/A
820-1C	N/A	04/13/78	1230	04/19/78	0815	134	T	N/A
821-1A	N/A	04/19/78	1545	04/25/78	0750	136	T	N/A
822-1A	N/A	04/25/78	1440	05/05/78	0740	232	T	N/A
822-1B	N/A	05/05/78	0740	05/10/78	0455	85	T	N/A
823-1A	N/A	05/12/78	1630	05/23/78	0800	205	T	N/A
824-1A	N/A	05/23/78	1435	05/30/78	0800	159	T	N/A
825-1A	N/A	05/30/78	1900	06/09/78	0800	229	T	N/A
826-1A	N/A	06/09/78	1335	06/19/78	1925	246	T	N/A
827-1A	N/A	//	N/A	//	N/A	N/A	N/A	N/A
828-1A	N/A	//	N/A	//	N/A	N/A	N/A	N/A
828-1B	N/A	//	N/A	//	N/A	N/A	N/A	N/A
829-1A	N/A	//	N/A	//	N/A	N/A	N/A	N/A
830-1A	N/A	//	N/A	//	N/A	N/A	N/A	N/A
851-1A	N/A	03/10/77	1450	03/15/77	0750	110	T	N/A
852-1A	N/A	03/15/77	1422	03/18/77	1550	74	T	N/A
853-1A	N/A	03/18/77	1550	03/25/77	0815	161	T	N/A
854-1A	N/A	03/25/77	1525	04/01/77	1315	166	T	N/A
855-1A	N/A	06/21/77	1510	06/28/77	1300	158	T	N/A
856-1A	N/A	06/28/77	1300	07/07/77	0815	209	T	900GPM TO TOP 2 HDRS(1600GPM TOTAL TO ST) 7/2-7/5/77.HIGHER SO2 REMOVAL
857-1A	N/A	07/07/77	1416	07/12/77	2150	128	T	N/A
858-1A	N/A	07/13/77	1355	07/20/77	0810	162	T	N/A
859-1A	N/A	07/20/77	1440	07/25/77	1000	115	T	N/A
859-1B	N/A	07/25/77	1000	07/28/77	0800	70	T	N/A
859-1C	N/A	07/28/77	0800	08/02/77	0750	120	T	N/A
859-1D	N/A	08/02/77	0750	08/05/77	1330	72	T	N/A
860-1A	N/A	08/05/77	1330	08/11/77	0537	133	T	N/A
861-1A	N/A	10/06/77	1125	10/11/77	0825	117	T	N/A
862-1A	N/A	10/11/77	1300	10/18/77	0720	162	T	N/A

VST RUN DEFINITION

RUN NO.	RUN REP FLAG	START DATE	START TIME	END DATE	END TIME	HOURS ON STRM	FACT OR TIME	RUN COMMENTS
863-1A	N/A	12/16/77	1615	01/20/78	1241	779	T	N/A
864-1A	N/A	01/20/78	1309	01/25/78	0755	115	T	N/A
865-1A	N/A	01/25/78	1008	02/14/78	0835	254	T	N/A
866-1A	N/A	02/14/78	1030	02/21/78	0855	159	T	N/A
867-1A	N/A	02/21/78	1430	02/27/78	0820	137	T	N/A

VST SYSTEM CONFIGURATION

RUN NO.	NO. OF SCRUBBER STAGES	S.T. HEADER CONFIG	NO.OF HOLD TANKS	M.E. SYSTEM CONFIG	M.E. WASH B/T	DE-WATER SYSTEM	OXID CONFIG FLAG	SPARGER HOLE DIAM., INCHES	NO. OF HOLES IN SPARGER	SPARGE TANK AGIT ATOR	ALK ADDN PT.	PRESCRUB ALKALI ADDITION POINT	RUN NO.
VFG-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	VFG-1A
VFG-1B	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	VFG-1B
VFG-1C	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	VFG-1C
VFG-1D	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	VFG-1D
VFG-1E	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	VFG-1E
VFG-1F	N/A	NONE	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	VFG-1F
VFG-1G	N/A	1234	1	CHE+YRK	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	VFG-1G
VFG-1I	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	VFG-1I
VFG-1P	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	VFG-1P
VFG-1Q	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	VFG-1Q
601-1A	N/A	1234	1	1-3P/OV	I	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	601-1A
601-1B	N/A	1234	1	1-3P/OV	I/	CL/FI	N/A	N/A	N/A	N/A	EHT	N/A	601-1B
601-1C	N/A	1234	1	1-3P/OV	I/	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	601-1C
602-1A	N/A	1234	1	1-3P/OV	I/	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	602-1A
603-1A	N/A	1234	1	1-3P/OV	I/	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	603-1A
604-1A	N/A	1234	1	1-3P/OV	I/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	604-1A
605-1A	N/A	1234	1	1-3P/OV	I/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	605-1A
606-1A	N/A	1234	1	1-3P/OV	C/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	606-1A
607-1A	N/A	1234	1	1-3P/OV	I/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	607-1A
608-1A	N/A	1234	1	1-3P/OV	I/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	608-1A
609-1A	N/A	1234	1	1-3P/OV	I/C	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	609-1A
610-1A	N/A	1234	1	1-3P/OV	I/C	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	610-1A
611-1A	N/A	1234	1	SLOPED	C/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	611-1A
612-1A	N/A	1234	1	SLOPED	C/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	612-1A
613-1A	N/A	NONE	1	SLOPED	C/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	613-1A
614-1A	N/A	1234	1	SLOPED	C/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	614-1A
614-1B	N/A	1234	1	SLOPED	C/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	614-1B
615-1A	N/A	1234	1	SLOPED	C/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	615-1A
615-1B	N/A	1234	1	SLOPED	C/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	615-1B
616-1A	N/A	NONE	1	SLOPED	C/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	616-1A
617-1A	N/A	NONE	1	SLOPED	C/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	617-1A
618-1A	N/A	1234	1	SLOPED	C/	CL	N/A	N/A	N/A	N/A	DNC	N/A	618-1A
619-1A	N/A	1234	1	SLOPED	I/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	619-1A
620-1A	N/A	1234	1	SLOPED	C/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	620-1A
621-1A	N/A	1234	1	SLOPED	C/	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	621-1A
622-1A	N/A	1234	1	1-3P/OV	I/	CL/CE	N/A	N/A	N/A	N/A	DNC	N/A	622-1A
623-1A	N/A	1234	1	1-3P/OV	I/I	CL/CE	N/A	N/A	N/A	N/A	DNC	N/A	623-1A
624-1A	N/A	1234	1	I-3P/OV	I/I	CL/CE	N/A	N/A	N/A	N/A	DNC	N/A	624-1A
625-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	625-1A
626-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	626-1A
627-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	627-1A
628-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	628-1A
628-1B	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	628-1B
629-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	629-1A

VST SYSTEM CONFIGURATION

RUN NO.	NO. OF SCRUBBER STAGES	S.T. HEADER CONFIG	NO.OF HOLD TANKS	M.E. SYSTEM CONFIG	M.E. WASH B/T	DE-WATER SYSTEM	OXID CONFIG FLAG	SPARGER HOLE DIAM., INCHES	NO. OF HOLES IN SPARGER	SPARGE TANK AGIT ATOR	ALK ADDN PT.	PRESCRUB ALKALI ADDITION POINT	RUN NO.
630-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	630-1A
631-1A	N/A	34	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	631-1A
632-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	632-1A
633-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	633-1A
634-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	634-1A
635-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	635-1A
636-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	636-1A
637-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	637-1A
638-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	638-1A
639-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	639-1A
640-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	640-1A
641-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	641-1A
642-1A	N/A	1 34	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	642-1A
643-1A	N/A	1234	1	1-3P/OV	I/I	CL/CE	N/A	N/A	N/A	N/A	DNC	N/A	643-1A
701-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	701-1A
702-1A	N/A	1234	1	1-3P/OV	I/I	CE	N/A	N/A	N/A	N/A	EHT	N/A	702-1A
703-1A	N/A	1234	1	1-3P/OV	I/I	CE	N/A	N/A	N/A	N/A	EHT	N/A	703-1A
704-1A	N/A	1234	1	1-3P/OV	I/I	CE	N/A	N/A	N/A	N/A	EHT	N/A	704-1A
705-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	705-1A
706-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	706-1A
707-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	707-1A
708-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	708-1A
709-1A	N/A	1234	1	1-3P/OV	C/I	CE	N/A	N/A	N/A	N/A	EHT	N/A	709-1A
710-1A	N/A	1234	1	1-3P/OV	C/I	CE	N/A	N/A	N/A	N/A	EHT	N/A	710-1A
711-1A	N/A	1234	1	1-3P/OV	C/I	CE	N/A	N/A	N/A	N/A	EHT	N/A	711-1A
711-1B	N/A	1234	1	1-3P/OV	C/I	CE	N/A	N/A	N/A	N/A	EHT	N/A	711-1B
712-1A	N/A	1234	1	1-3P/OV	C/I	CE	N/A	N/A	N/A	N/A	EHT	N/A	712-1A
712-1B	N/A	1234	1	1-3P/OV	C/I	CE	N/A	N/A	N/A	N/A	-	N/A	712-1B
713-1A	N/A	1234	1	1-3P/OV	C/I	CE	N/A	N/A	N/A	N/A	EHT	N/A	713-1A
714-1A	N/A	1234	1	1-3P/OV	I/I	CE	N/A	N/A	N/A	N/A	EHT	N/A	714-1A
715-1A	N/A	1234	1	1-3P/OV	I/I	CE	N/A	N/A	N/A	N/A	EHT	N/A	715-1A
716-1A	N/A	1234	1	1-3P/OV	I/I	CE	N/A	N/A	N/A	N/A	EHT	N/A	716-1A
717-1A	N/A	1234	1	1-3P/OV	I/I	CE	N/A	N/A	N/A	N/A	EHT	N/A	717-1A
718-1A	N/A	1234	1	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	DNC	N/A	718-1A
801-1A	2	1234	1	1-3P/OV	I/I	CL/F	N/A	0.125	130	Y	EHT	N/A	801-1A
801-2A	2	N/A	N/A	N/A	N/A	N/A	2	0.126	130	Y	N/A	ONC	801-2A
802-1A	2	1234	1	1-3P/OV	I/I	CL/F	N/A	0.125	130	Y	EHT	N/A	802-1A
803-1A	2	1234	1	1-3P/OV	I/I	CL/F	N/A	0.125	130	Y	EHT	N/A	803-1A
804-1A	2	1234	1	1-3P/OV	I/I	CL/F	N/A	0.125	130	Y	EHT	N/A	804-1A
805-1A	2	1234	1	1-3P/OV	I/I	CL/F	N/A	0.125	130	Y	EHT	N/A	805-1A
806-1A	2	1234	1	1-3P/OV	I/I	CL/F	N/A	0.125	130	Y	EHT	N/A	806-1A
806-1B	2	1234	1	1-3P/OV	I/I	CL/F	N/A	0.125	130	Y	EHT	N/A	806-1B
806-1C	2	1234	1	1-3P/OV	I/I	CL/F	N/A	0.125	130	Y	EHT	N/A	806-1C
806-1D	2	1234	1	1-3P/OV	I/I	CL/F	N/A	0.125	130	Y	EHT	N/A	806-1D

VST SYSTEM CONFIGURATION

RUN NO.	NO. OF SCRUBBER STAGES	S.T. HEADER CONFIG	NO.OF HOLD TANKS	M.E. SYSTEM CONFIG	M.E. WASH B/T	DE-WATER SYSTEM	OXID CONFIG FLAG	SPARGER HOLE DIAM., INCHES	NO. OF HOLES IN SPARGER	SPARGE TANK AGIT ATOR	ALK ADDN PT.	PRESCRUB ALKALI ADDITION POINT	RUN NO.
807-1A	2	1234	1	1-3P/OV	I/I	CL/F	N/A	0.125	130	Y	EHT	N/A	807-1A
808-1A	2	1234	1	1-3P/OV	I/I	CL/F	N/A	0.125	130	Y	EHT	N/A	808-1A
809-1A	2	1234	3	1-3P/OV	C/I	CL/F/L	N/A	0.250	40	Y	EHT	N/A	809-1A
810-1A	2	1234	3	1-3P/OV	C/I	CL	N/A	0.250	40	Y	EHT	N/A	810-1A
811-1A	2	1234	3	1-3P/OV	C/I	CL	N/A	0.250	40	Y	EHT	N/A	811-1A
812-1A	2	1234	3	1-3P/OV	C/I	CL/F	N/A	0.250	40	Y	EHT	N/A	812-1A
813-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	813-1A
814-1A	2	1234	3	1-3P/OV	C/I	CL/F	N/A	0.250	40	Y	EHT	N/A	814-1A
815-1A	2	1234	3	1-3P/OV	C/I	CL/F	N/A	0.250	40	Y	EHT	N/A	815-1A
816-1A	2	1234	3	1-3P/OV	C/I	CL/F	N/A	0.250	40	Y	EHT	N/A	816-1A
817-1A	2	1234	3	1-3P/OV	C/I	CL/F	N/A	0.300	1	Y	EHT	N/A	817-1A
818-1A	2	1234	3	1-3P/OV	C/I	CL/F/L	N/A	0.300	1	Y	EHT	N/A	818-1A
819-1A	N/A	1234	3	1-3P/OV	C/I	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	819-1A
819-1B	N/A	1234	3	1-3P/OV	C/I	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	819-1B
820-1A	2	1234	N/A	1-3P/OV	C/S	CL/F	N/A	N/A	1	Y	EHT	N/A	820-1A
820-1B	2	1234	N/A	1-3P/OV	C/S	CL/F	N/A	N/A	1	Y	EHT	N/A	820-1B
820-1C	2	1234	N/A	1-3P/OV	C/S	CL/F	N/A	N/A	N/A	Y	EHT	N/A	820-1C
821-1A	1	N/A	N/A	1-3P/OV	C/S	CL/F	4	N/A	1	Y	EHT	N/A	821-1A
822-1A	2	1234	N/A	1-3P/OV	C/S	CL/F	N/A	N/A	1	Y	EHT	N/A	822-1A
822-1B	2	1234	N/A	1-3P/OV	C/S	CL/F	N/A	N/A	1	Y	EHT	N/A	822-1B
823-1A	1	1234	N/A	1-3P/OV	C/S	CL/F	N/A	N/A	1	Y	EHT	N/A	823-1A
824-1A	1	1234	N/A	1-3P/OV	C/S	CL/F	N/A	N/A	1	Y	EHT	N/A	824-1A
825-1A	1	1234	N/A	1-3P/OV	C/S	CL/F	N/A	N/A	1	Y	EHT	N/A	825-1A
826-1A	1	1234	N/A	1-3P/OV	C/S	CL/F	N/A	N/A	1	Y	EHT	N/A	826-1A
827-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	827-1A
828-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	828-1A
828-1B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	828-1B
829-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	829-1A
830-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	830-1A
851-1A	2	1234	1	1-3P/OV	I/I	CL/F	N/A	0.125	130	Y	DNC	DNC	851-1A
852-1A	2	1234	1	1-3P/OV	I/I	CL/F	N/A	0.125	130	Y	DNC	DNC	852-1A
853-1A	2	1234	1	1-3P/OV	I/I	CL/F	N/A	0.125	130	Y	DNC	DNC	853-1A
854-1A	2	1234	1	1-3P/OV	I/I	CL/F	N/A	0.125	130	Y	DNC	DNC	854-1A
855-1A	2	1234	3			CL/F	1	0.250	40	Y	EHT	DNC	855-1A
856-1A	2	1234	3	1-3P/OV	I/I	CL/F	N/A	0.250	40	Y	EHT	DNC	856-1A
857-1A	2	1234	3	1-3P/OV	I/I	CL/F	N/A	0.250	40	Y	EHT	DNC	857-1A
858-1A	2	1234	3	1-3P/OV	I/I	CL/F	N/A	0.250	40	Y	EHT	DNC	858-1A
859-1A	2	1234	3	1-3P/OV	I/I	CL/F	N/A	0.250	40	Y	EHT	DNC	859-1A
859-1B	2	1234	3	1-3P/OV	I/I	CL/F	N/A	0.250	40	Y	EHT	DNC	859-1B
859-1C	2	1234	3	1-3P/OV	I/I	CL/F	N/A	0.250	40	Y	EHT	DNC	859-1C
859-1D	2	1234	3	1-3P/OV	I/I	CL/F	N/A	0.250	40	Y	EHT	DNC	859-1D
860-1A	2	1234	3	1-3P/OV	I/I	CL/F	N/A	0.250	40	Y	EHT	DNC	860-1A
861-1A	2	1234	3	1-3P/OV	I/I	CL/F	N/A	0.300	1	N/A	EHT	DNC	861-1A
862-1A	2	1234	3	1-3P/OV	I/I	CL/F	N/A	0.300	1	N/A	N/A	DNC	862-1A

VST SYSTEM CONFIGURATION

RUN NO.	NO. OF SCRUBBER STAGES	S.T. HEADER CONFIG	NO.OF HOLD TANKS	M.E. SYSTEM CONFIG	M.E. WASH B/T	DE-WATER SYSTEM	OXID CONFIG FLAG	SPARGER HOLE DIAM., INCHES	NO. OF HOLES IN SPARGER	SPARGE TANK AGIT ATOR	ALK ADDN PT.	PRESCRUB ALKALI ADDITION POINT	RUN NO.
863-1A	N/A	1234	N/A	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	863-1A
864-1A	N/A	1234	N/A	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	864-1A
865-1A	N/A	1234	N/A	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	865-1A
866-1A	N/A	1234	N/A	1-3P/OV	I/I	CL/F	N/A	N/A	N/A	N/A	EHT	N/A	866-1A
867-1A	2	1234	N/A	1-3P/OV	I/S	CL/F	N/A	N/A	1	Y	EHT	DNC	867-1A

VST OPERATING CONDITIONS

RUN NO.	ALK TYPE	FLY ASH	MGO	PH CONTR POINT	PRESCRUB VENTURI PH CONTR POINT	GAS RATE ACFM	GAS VEL FPS	VEN LIQ RATE GPM	S.T. LIQ RATE GPM	VEN L/G GAL/MACF	S.T. L/G GAL/MACF	SOLID RECIRC NOM %	PRESCRUB VEN NOM % SOLIDS RECIRC	SOLIDS DISCH RANGE %	RUN NO.
VFG-1A	L	Y	Y	7.00	N/A	35000	9.4	600	1400	21.4	49.8	8.0	N/A	48-57	VFG-1A
VFG-1B	L	N	N	8.00	N/A	35000	9.4	600	1400	21.4	49.8	8.0	N/A	42-62	VFG-1B
VFG-1C	L	Y	N	8.00	N/A	35000	9.4	600	1400	21.4	49.8	8.0	N/A	53-60	VFG-1C
VFG-1D	L	Y	N	8.00	N/A	20000	5.4	600	1400	37.4	87.2	8.0	N/A	51-57	VFG-1D
VFG-1E	L	Y	N	8.00	N/A	35000	9.4	375	1400	13.4	49.8	8.0	N/A	45-63	VFG-1E
VFG-1F	L	Y	N	8.00	N/A	35000	9.4	600	0	21.4	0.0	8.0	N/A	59-64	VFG-1F
VFG-1G	L	Y	N	8.00	N/A	35000	9.4	600	1400	21.4	49.8	8.0	N/A	51-54	VFG-1G
VFG-1I	L	Y	N	8.00	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	52-55	VFG-1I
VFG-1P	L	Y	N	8.00	N/A	35000	9.4	140	1400	5.0	49.8	8.0	N/A	55-60	VFG-1P
VFG-1Q	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	VFG-1Q
601-1A	L	Y	N	8.00	N/A	25000	6.7	600	1200	29.9	59.8	8.0	N/A	20-52	601-1A
601-1B	L	Y	N	8.00	N/A	25000	6.7	600	1200	29.9	59.8	8.0	N/A	N/A	601-1B
601-1C	L	Y	N	8.00	N/A	25000	6.7	600	1200	29.9	59.8	8.0	N/A	20-52	601-1C
602-1A	L	Y	N	8.00	N/A	25000	6.7	600	1200	29.9	59.8	8.5	N/A	42-48	602-1A
603-1A	L	Y	N	8.00	N/A	25000	6.7	600	1200	29.9	59.8	15.0	N/A	46-54	603-1A
604-1A	L	Y	N	8.00	N/A	25000	6.7	100	1200	5.0	59.8	8.0	N/A	50-60	604-1A
605-1A	L	Y	N	9.00	N/A	25000	6.7	100	1200	5.0	59.8	8.5	N/A	48-52	605-1A
606-1A	L	Y	N	8.00	N/A	25000	6.7	100	1200	5.0	59.8	8.5	N/A	18-23	606-1A
607-1A	L	Y	N	8.00	N/A	25000	6.7	600	1200	29.9	59.8	8.0	N/A	50-55	607-1A
608-1A	L	Y	N	8.00	N/A	25000	6.7	600	1200	29.9	59.8	8.5	N/A	48-58	608-1A
609-1A	L	Y	N	8.00	N/A	25000	6.7	600	1200	29.9	59.8	8.5	N/A	47-52	609-1A
610-1A	L	Y	N	8.00	N/A	25000	6.7	600	1200	29.9	59.8	8.0	N/A	43-48	610-1A
611-1A	L	Y	Y	7.00	N/A	25000	6.7	600	1200	29.9	59.8	8.5	N/A	44-49	611-1A
612-1A	L	Y	Y	6.00	N/A	25000	6.7	600	1200	29.9	59.8	8.0	N/A	N/A	612-1A
613-1A	L	Y	Y	6.00	N/A	25000	6.7	600	0	29.9	0.0	8.0	N/A	N/A	613-1A
614-1A	L	Y	Y	6.00	N/A	25000	6.7	100	1200	5.0	59.8	8.0	N/A	N/A	614-1A
614-1B	L	Y	Y	6.00	N/A	25000	6.7	100	1200	5.0	59.8	8.0	N/A	N/A	614-1B
615-1A	L	Y	Y	7.00	N/A	25000	6.7	100	1200	5.0	59.8	8.0	N/A	N/A	615-1A
615-1B	L	Y	Y	7.00	N/A	25000	6.7	100	1200	5.0	59.8	8.0	N/A	N/A	615-1B
616-1A	L	Y	Y	7.00	N/A	25000	6.7	600	0	29.9	0.0	8.0	N/A	N/A	616-1A
617-1A	L	Y	Y	6.00	N/A	25000	6.7	100	0	5.0	0.0	8.0	N/A	N/A	617-1A
618-1A	L	Y	N	8.00	N/A	25000	6.7	100	1200	5.0	59.8	8.0	N/A	16-21	618-1A
619-1A	L	Y	N	8.00	N/A	25000	6.7	600	1200	29.9	59.8	8.5	N/A	53-60	619-1A
620-1A	L	Y	N	8.00	N/A	25000	6.7	600	1200	29.9	59.8	60.0	N/A	N/A	620-1A
621-1A	L	Y	N	8.00	N/A	25000	6.7	600	1200	29.9	59.8	8.5	N/A	57-61	621-1A
622-1A	L	Y	N	8.00	N/A	25000	6.7	600	1200	29.9	59.8	8.0	N/A	50-62	622-1A
623-1A	L	Y	N	8.00	N/A	25000	6.7	600	1200	29.9	59.8	8.0	N/A	53-60	623-1A
624-1A	L	Y	N	8.00	N/A	30000	8.0	600	1200	24.9	49.8	8.5	N/A	48-58	624-1A
625-1A	L	Y	N	8.00	N/A	30000	8.0	600	1200	24.9	49.8	8.0	N/A	55-60	625-1A
626-1A	L	Y	N	8.00	N/A	35000	9.4	600	1400	21.4	49.8	8.0	N/A	52-60	626-1A
627-1A	L	Y	N	8.00	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	52-56	627-1A
628-1A	L	Y	N	5.00	N/A	30000	8.0	600	1600	24.9	66.5	10.0	N/A	51-55	628-1A
628-1B	L	Y	N	5.00	N/A	30000	8.0	600	1600	24.9	66.5	9.0	N/A	52-56	628-1B
629-1A	L	Y	Y	6.00	N/A	35000	9.4	600	1400	21.4	49.8	8.0	N/A	52-60	629-1A

VST OPERATING CONDITIONS (CONTINUED)

RUN NO.	VEN D.P. IN. H2O	S.T. D.P. IN. H2O	M.E.SYSTEM D.P.RANGE IN.H2O	EFFLU RES TIME MIN	SPARGE TANK RESID TIME MIN.	VENTURI DESUP TANK RES TIME MIN.	SPARGE TANK LEVEL FEET	OXID AIR RATE SCFM	EDUCTOR CIRCUL RATE GPM	BLEED TO OX TANK GPM	BLEED OXID TANK PH	H2SO4 RATE GPM	RUN NO.
VFG-1A	9.0	4.0	0.44-0.49	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	VFG-1A
VFG-1B	9.0	4.3	0.45-0.50	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	VFG-1B
VFG-1C	9.0	4.5	0.45-0.50	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	VFG-1C
VFG-1D	9.0	1.4	0.11-0.15	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	VFG-1D
VFG-1E	5.3	4.2	0.43-0.50	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	VFG-1E
VFG-1F	9.0	3.5	0.37-0.45	20.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	VFG-1F
VFG-1G	9.0	4.6	0.79-1.75	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	VFG-1G
VFG-1I	9.0	4.5	0.38-0.44	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	VFG-1I
VFG-1P	3.6	3.9	0.35-0.42	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	VFG-1P
VFG-1Q	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	VFG-1Q
601-1A	9.0	2.7	0.16-1.26	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	601-1A
601-1B	9.0	2.7	N/A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	601-1B
601-1C	9.0	2.7	0.16-1.26	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	601-1C
602-1A	9.0	2.5	0.19-0.27	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	602-1A
603-1A	9.0	2.2	0.16-0.33	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	603-1A
604-1A	1.3	1.5	0.20-1.25	17.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	604-1A
605-1A	1.8	1.5	0.23-0.28	17.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	605-1A
606-1A	2.1	1.3	0.23-0.31	17.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	606-1A
607-1A	9.0	2.2	0.75-0.85	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	607-1A
608-1A	9.0	3.4	0.22-0.44	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	608-1A
609-1A	9.0	2.5	0.23-0.28	24.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	609-1A
610-1A	9.0	2.6	0.20-0.33	24.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	610-1A
611-1A	9.0	2.2	0.55-0.60	6.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	611-1A
612-1A	9.0	3.1	0.55-0.75	6.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	612-1A
613-1A	9.0	2.2	0.67-0.69	18.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	613-1A
614-1A	1.7	2.0	0.71-0.83	8.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	614-1A
614-1B	2.5	2.8	0.93-2.76	8.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	614-1B
615-1A	2.0	2.8	0.80-0.84	8.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	615-1A
615-1B	2.7	2.6	0.89-0.91	18.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	615-1B
616-1A	9.0	2.4	0.89-0.91	18.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	616-1A
617-1A	1.7	1.4	1.79-0.89	18.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	617-1A
618-1A	1.8	2.1	0.50-0.60	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	618-1A
619-1A	9.0	2.4	0.60-1.10	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	619-1A
620-1A	9.0	3.3	0.55-0.80	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	620-1A
621-1A	9.0	2.7	0.63-0.70	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	621-1A
622-1A	9.0	2.8	0.20-0.70	17.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	622-1A
623-1A	9.0	2.5	0.17-0.20	17.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	623-1A
624-1A	9.0	3.2	0.95-1.05	17.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	624-1A
625-1A	9.0	3.1	0.15-0.30	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	625-1A
626-1A	9.0	5.6	0.37-0.40	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	626-1A
627-1A	9.0	5.7	0.37-0.42	20.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	627-1A
628-1A	9.0	3.3	0.08-0.45	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	628-1A
628-1B	9.0	N/A	0.10-0.40	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	628-1B
629-1A	9.0	4.6	0.40-0.55	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	629-1A

VST OPERATING CONDITIONS

RUN NO.	ALK TYPE	FLY ASH	MGO	PH CONTR POINT	PRESCRUB VENTURI PH CONTR POINT	GAS RATE ACFM	GAS VEL FPS	VEN LIQ RATE GPM	S.T. LIQ RATE GPM	VEN L/G GAL/ MACF	S.T. L/G GAL/ MACF	SOLID RECIRC NOM %	PRESCRUB VEN NOM % SOLIDS RECIRC	SOLIDS DISCH RANGE %	RUN NO.
630-1A	L	Y	Y	7.00	N/A	35000	9.4	600	1400	21.4	49.8	8.0	N/A	50-56	630-1A
631-1A	L	Y	Y	7.00	N/A	35000	9.4	600	700	21.4	24.9	8.0	N/A	53-59	631-1A
632-1A	L	Y	Y	7.00	N/A	35000	9.4	140	1400	5.0	49.8	8.0	N/A	52-56	632-1A
633-1A	L	Y	Y	7.00	N/A	25000	6.7	140	1400	7.0	69.8	8.0	N/A	49-53	633-1A
634-1A	L	N	N	8.00	N/A	35000	9.4	600	1400	21.4	49.8	4.0	N/A	51-65	634-1A
635-1A	L	N	N	8.00	N/A	35000	9.4	600	1400	21.4	49.8	8.5	N/A	42-52	635-1A
636-1A	L	N	N	8.00	N/A	25000	6.7	600	1400	29.9	69.8	8.0	N/A	42-46	636-1A
637-1A	L	N	N	8.00	N/A	35000	9.4	600	1400	21.4	49.8	8.0	N/A	44-50	637-1A
638-1A	L	N	N	8.00	N/A	35000	9.4	600	1400	21.4	49.8	4.0	N/A	47-59	638-1A
639-1A	L	N	Y	7.00	N/A	35000	9.4	600	1400	21.4	49.8	4.0	N/A	44-54	639-1A
640-1A	L	N	Y	7.00	N/A	35000	9.4	600	1400	21.4	49.8	8.0	N/A	48-51	640-1A
641-1A	L	N	Y	7.00	N/A	35000	9.4	140	1400	5.0	49.8	8.0	N/A	45-50	641-1A
642-1A	L	N	Y	7.00	N/A	35000	9.4	140	1050	5.0	37.4	8.0	N/A	45-57	642-1A
643-1A	L	N	Y	7.00	N/A	35000	9.4	600	1400	21.4	49.8	8.0	N/A	41-46	643-1A
701-1A	LS	Y	N	5.90	N/A	35000	9.4	600	1600	21.4	57.0	15.0	N/A	58-63	701-1A
702-1A	LS	Y	N	5.90	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	58-65	702-1A
703-1A	LS	Y	N	5.90	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	60-67	703-1A
704-1A	LS	Y	N	5.90	N/A	35000	9.4	600	1500	21.4	53.4	15.0	N/A	59-65	704-1A
705-1A	LS	Y	N	5.50	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	53-66	705-1A
706-1A	LS	Y	N	5.20	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	54-75	706-1A
707-1A	LS	Y	N	N/A	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	58-73	707-1A
708-1A	LS	Y	N	N/A	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	59-65	708-1A
709-1A	LS	Y	N	N/A	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	61-65	709-1A
710-1A	LS	Y	N	N/A	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	57-63	710-1A
711-1A	LS	Y	N	5.60	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	59-65	711-1A
711-1B	LS	Y	N	N/A	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	56-62	711-1B
712-1A	LS	Y	N	N/A	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	60-63	712-1A
712-1B	LS	Y	N	N/A	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	N/A	712-1B
713-1A	LS	Y	N	5.20	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	59-60	713-1A
714-1A	LS	Y	Y	N/A	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	57-62	714-1A
715-1A	LS	Y	Y	N/A	N/A	35000	9.4	600	0	21.4	0.0	15.0	N/A	56-66	715-1A
716-1A	LS	Y	Y	N/A	N/A	35000	9.4	600	0	21.4	0.0	15.0	N/A	70-73	716-1A
717-1A	LS	Y	Y	N/A	N/A	35000	9.4	600	1400	21.4	49.8	15.0	N/A	53-59	717-1A
718-1A	LS	N	N	N/A	N/A	35000	9.4	600	1400	21.4	49.8	8.0	N/A	50-61	718-1A
801-1A	LS	Y	N	N/A	4.50	25000	6.7	400	1300	19.9	64.8	8.0	15.0	N/A	801-1A
801-2A	N/A	N/A	N/A	N/A	4.50	N/A	N/A	N/A	N/A	N/A	N/A	N/A	15.0	N/A	801-2A
802-1A	LS	Y	N	N/A	5.00	25000	6.7	400	1400	19.9	69.8	8.0	15.0	N/A	802-1A
803-1A	LS	Y	N	N/A	5.00	25000	6.7	600	1400	29.9	69.8	8.0	15.0	N/A	803-1A
804-1A	LS	Y	N	N/A	5.00	25000	6.7	600	1400	29.9	69.8	N/A	15.0	N/A	804-1A
805-1A	LS	Y	N	N/A	5.00	25000	6.7	600	1400	29.9	69.8	N/A	15.0	N/A	805-1A
806-1A	LS	Y	N	N/A	4.50	25000	6.7	600	1400	29.9	69.8	N/A	15.0	N/A	806-1A
806-1B	LS	Y	N	N/A	4.50	25000	6.7	600	1400	29.9	69.8	N/A	15.0	N/A	806-1B
806-1C	LS	Y	N	N/A	4.50	25000	6.7	600	1400	29.9	69.8	N/A	15.0	N/A	806-1C
806-1D	LS	Y	N	N/A	4.50	25000	6.7	600	1400	29.9	69.8	N/A	15.0	N/A	806-1D

VST OPERATING CONDITIONS (CONTINUED)

RUN NO.	VEN D.P. IN. H2O	S.T. D.P. IN. H2O	M.E.SYSTEM D.P.RANGE IN.H2O	EFFLU RES TIME MIN	SPARGE TANK RESID TIME MIN.	VENTURI DESUP TANK RES TIME MIN.	SPARGE TANK LEVEL FEET	OXID AIR RATE SCFM	EDUCTOR CIRCUL RATE GPM	BLEED TO OX TANK GPM	BLEED OXID TANK PH	H2SO4 RATE GPM	RUN NO.
630-1A	9.0	4.4	0.40-0.50	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	630-1A
631-1A	9.0	4.5	0.40-0.48	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	631-1A
632-1A	2.8	4.3	0.40-0.45	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	632-1A
633-1A	1.8	2.1	0.21-0.24	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	633-1A
634-1A	9.0	4.0	0.46-0.51	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	634-1A
635-1A	9.0	4.3	0.46-0.51	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	635-1A
636-1A	9.0	2.0	0.23-0.26	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	636-1A
637-1A	9.0	4.0	0.45-0.48	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	637-1A
638-1A	9.0	3.7	0.45-0.48	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	638-1A
639-1A	9.0	4.2	0.47-0.59	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	639-1A
640-1A	9.0	4.5	0.45-0.52	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	640-1A
641-1A	3.6	3.2	0.48-0.51	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	641-1A
642-1A	3.5	3.5	0.48-0.51	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	642-1A
643-1A	9.0	4.0	0.41-0.48	3.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	643-1A
701-1A	9.0	5.7	0.35-0.70	20.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	701-1A
702-1A	9.0	5.3	0.35-0.60	20.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	702-1A
703-1A	9.0	5.5	0.30-0.40	20.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	703-1A
704-1A	9.0	5.6	0.35-0.76	20.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	704-1A
705-1A	9.0	5.6	0.35-0.43	20.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	705-1A
706-1A	9.0	5.9	0.30-0.40	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	706-1A
707-1A	9.0	5.5	0.25-0.43	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	707-1A
708-1A	9.0	6.0	0.43-0.55	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	708-1A
709-1A	9.0	5.0	0.33-0.40	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	709-1A
710-1A	9.0	5.7	0.33-0.40	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	710-1A
711-1A	9.0	6.0	0.35-0.40	6.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	711-1A
711-1B	9.0	6.0	0.33-0.38	6.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	711-1B
712-1A	9.0	5.9	0.36-0.40	6.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	712-1A
712-1B	9.0	6.4	0.35-0.40	6.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	712-1B
713-1A	9.0	5.8	0.38-0.40	6.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	713-1A
714-1A	9.0	6.1	0.33-0.40	6.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	714-1A
715-1A	9.0	4.5	0.35-0.40	20.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	715-1A
716-1A	9.0	4.4	0.35-0.40	20.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	716-1A
717-1A	9.0	5.6	0.25-0.50	6.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	717-1A
718-1A	9.0	4.0	0.47-0.52	12.0	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	718-1A
801-1A	9.0	N/A	N/A	19.4	17.0	7.0	18.0	400	N/A	N/A	N/A	N/A	801-1A
801-2A	N/A	N/A	N/A	N/A	17.0	7.0	18.0	400	1590	N/A	N/A	N/A	801-2A
802-1A	9.0	N/A	N/A	18.0	17.0	7.0	18.0	400	N/A	N/A	N/A	N/A	802-1A
803-1A	9.0	N/A	N/A	18.0	11.3	4.7	18.0	400	N/A	N/A	N/A	N/A	803-1A
804-1A	9.0	N/A	N/A	18.0	11.3	4.7	18.0	400	N/A	N/A	N/A	N/A	804-1A
805-1A	9.0	N/A	N/A	18.0	11.3	4.7	18.0	400	N/A	N/A	N/A	N/A	805-1A
806-1A	9.0	N/A	N/A	18.0	11.3	4.7	18.0	250	N/A	N/A	N/A	N/A	806-1A
806-1B	9.0	N/A	N/A	18.0	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	806-1B
806-1C	9.0	N/A	N/A	18.0	11.3	4.7	18.0	100	N/A	N/A	N/A	N/A	806-1C
806-1D	9.0	N/A	N/A	18.0	11.3	4.7	18.0	50	N/A	N/A	N/A	N/A	806-1D

VST OPERATING CONDITIONS

RUN NO.	ALK TYPE	FLY ASH	MGO	PH CONTR POINT	PRESCRUB VENTURI PH CONTR POINT	GAS RATE ACFM	GAS VEL FPS	VEN LIQ RATE GPM	S.T. LIQ RATE GPM	VEN L/G GAL/ MACF	S.T. L/G GAL/ MACF	SOLID RECIRC NOM %	PRESCRUB VEN NOM % SOLIDS RECIRC	SOLIDS DISCH RANGE %	RUN NO.
807-1A	LS	Y	N	N/A	4.50	25000	6.7	600	1400	29.9	69.8	N/A	15.0	N/A	807-1A
808-1A	LS	Y	N	N/A	4.50	25000	6.7	600	1400	29.9	69.8	N/A	15.0	N/A	808-1A
809-1A	LS	N	N	N/A	4.50	25000	6.7	600	1400	29.9	69.8	7.8	15.0	72-88	809-1A
810-1A	LS	N	N	N/A	5.00	25000	6.7	600	1400	29.9	69.8	8.0	15.0	37-55	810-1A
811-1A	LS	N	N	N/A	5.50	25000	6.7	600	1400	29.9	69.8	8.0	15.0	38-52	811-1A
812-1A	LS	N	N	N/A	5.50	25000	6.7	600	1400	29.9	69.8	7.0	15.0	80.92	812-1A
813-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	813-1A
814-1A	LS	N	N	N/A	5.50	25000	6.7	600	1400	29.9	69.8	8.4	15.0	84-92	814-1A
815-1A	LS	N	N	N/A	5.50	35000	9.4	600	1400	21.4	49.8	8.4	15.0	82-92	815-1A
816-1A	LS	N	N	N/A	5.50	35000	9.4	600	1400	21.4	49.8	7.6	15.0	81-91	816-1A
817-1A	LS	Y	N	5.50	5.50	35000	9.4	600	1400	21.4	49.8	8.8	15.0	82-89	817-1A
818-1A	LS	Y	N	5.50	5.50	35000	9.4	600	1600	21.4	57.0	9.6	15.0	82-89	818-1A
819-1A	LS	Y	N	5.50	N/A	N/A	N/A	600	1600	N/A	N/A	10.0	N/A	83-91	819-1A
819-1B	LS	Y	N	N/A	N/A	N/A	N/A	600	1600	N/A	N/A	15.2	N/A	82-89	819-1B
820-1A	LS	Y	Y	N/A	5.50	35000	9.4	600	1600	21.4	57.0	6.0	15.0	82-88	820-1A
820-1B	LS	Y	Y	N/A	N/A	35000	9.4	600	1600	21.4	57.0	8.2	15.0	78-86	820-1B
820-1C	LS	Y	Y	N/A	N/A	35000	9.4	600	1600	21.4	57.0	10.5	15.0	55-71	820-1C
821-1A	LS	Y	Y	N/A	N/A	35000	9.4	600	N/A	21.4	N/A	N/A	15.0	N/A	821-1A
822-1A	LS	Y	Y	N/A	N/A	35000	9.4	600	1600	21.4	57.0	8.0	15.0	80-90	822-1A
822-1B	LS	Y	Y	N/A	N/A	35000	9.4	600	1600	21.4	57.0	5.6	15.0	80-89	822-1B
823-1A	LS	Y	Y	N/A	N/A	18000	4.8	600	1600	41.5	110.8	13.3	N/A	79-87	823-1A
824-1A	LS	Y	Y	N/A	N/A	35000	9.4	600	1600	21.4	57.0	14.1	N/A	80-90	824-1A
825-1A	LS	Y	Y	N/A	N/A	18000	4.8	600	1600	41.5	110.8	14.7	N/A	82-88	825-1A
826-1A	LS	Y	Y	N/A	N/A	26500	7.1	600	1600	28.2	75.2	15.2	N/A	80-88	826-1A
827-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	827-1A
828-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	828-1A
828-1B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	828-1B
829-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	829-1A
830-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	830-1A
851-1A	L	Y	N	N/A	4.50	25000	6.7	600	600	29.9	29.9	15.0	15.0	74-88	851-1A
852-1A	L	Y	N	N/A	4.50	25000	6.7	160	1400	8.0	69.8	15.0	15.0	65-80	852-1A
853-1A	L	Y	N	N/A	4.50	25000	6.7	600	1400	29.9	69.8	15.0	15.0	73-83	853-1A
854-1A	L	Y	N	N/A	5.20	25000	6.7	600	1400	29.9	69.8	15.0	15.0	75-83	854-1A
855-1A	L	N	N	8.00	4.50	25000	6.7	600	1400	29.9	69.8	7.3	15.0	62-88	855-1A
856-1A	L	N	N	8.00	5.00	25000	6.7	600	1400	29.9	69.8	7.8	15.0	75-90	856-1A
857-1A	L	N	N	8.00	5.50	25000	6.7	600	1400	29.9	69.8	7.8	15.0	70-86	857-1A
858-1A	L	N	N	8.00	5.50	25000	6.7	600	1400	29.9	69.8	15.2	8.0	72-90	858-1A
859-1A	L	N	N	8.00	5.50	25000	6.7	600	1400	29.9	69.8	7.2	15.0	64-83	859-1A
859-1B	L	N	N	8.00	5.50	25000	6.7	600	1400	29.9	69.8	7.6	15.0	69-86	859-1B
859-1C	L	N	N	8.00	5.50	25000	6.7	600	1400	29.9	69.8	7.3	15.0	64-77	859-1C
859-1D	L	N	N	8.00	5.50	25000	6.7	600	1400	29.9	69.8	7.0	15.0	52-57	859-1D
860-1A	L	N	N	8.00	5.50	25000	6.7	600	1400	29.9	69.8	7.0	15.0	74-89	860-1A
861-1A	L	N	N	8.00	5.50	25000	6.7	600	1400	29.9	69.8	7.2	15.0	82-90	861-1A
862-1A	L	Y	N	8.00	5.50	35000	9.4	600	1400	21.4	49.8	17.3	15.0	82-89	862-1A

VST OPERATING CONDITIONS (CONTINUED)

RUN NO.	VEN D.P. IN. H2O	S.T. D.P. IN. H2O	M.E.SYSTEM D.P.RANGE IN.H2O	EFFLU RES TIME MIN	SPARGE TANK RESID TIME MIN.	VENTURI DESUP TANK RES TIME MIN.	SPARGE TANK LEVEL FEET	OXID AIR RATE SCFM	EDUCTOR CIRCUL RATE GPM	BLEED TO OX TANK GPM	BLEED OXID TANK PH	H2SO4 RATE GPM	RUN NO.
807-1A	9.0	N/A	N/A	18.0	11.3	4.7	18.0	N/A	N/A	N/A	N/A	N/A	807-1A
808-1A	9.0	N/A	N/A	18.0	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	808-1A
809-1A	9.0	2.8	0.29-0.35	13.4	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	809-1A
810-1A	9.0	2.7	0.29-0.32	13.4	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	810-1A
811-1A	9.0	2.6	0.30-0.34	13.4	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	811-1A
812-1A	9.0	2.9	0.31-0.36	13.4	11.3	N/A	18.0	150	N/A	N/A	N/A	N/A	812-1A
813-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	813-1A
814-1A	9.0	3.0	0.32-0.38	13.4	8.8	4.7	14.0	150	N/A	N/A	N/A	N/A	814-1A
815-1A	9.0	7.0	0.58-0.76	13.4	8.8	4.7	14.0	210	N/A	N/A	N/A	N/A	815-1A
816-1A	9.0	6.8	0.56-0.70	13.4	11.3	4.7	18.0	210	N/A	N/A	N/A	N/A	816-1A
817-1A	9.0	6.3	0.55-0.66	16.8	11.3	4.7	18.0	210	N/A	N/A	N/A	N/A	817-1A
818-1A	9.0	6.0	0.57-0.68	14.7	11.3	4.7	18.0	210	N/A	N/A	N/A	N/A	818-1A
819-1A	6.2	4.6	0.18-0.86	14.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	819-1A
819-1B	7.3	5.3	0.24-0.82	14.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	819-1B
820-1A	9.0	N/A	0.52-0.68	14.7	11.3	4.7	18.0	210	N/A	N/A	N/A	N/A	820-1A
820-1B	9.0	N/A	0.58-0.66	14.7	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	820-1B
820-1C	9.0	N/A	0.43-0.72	14.7	11.3	4.7	18.0	N/A	N/A	N/A	N/A	N/A	820-1C
821-1A	9.0	N/A	N/A	14.7	11.3	4.7	18.0	210	N/A	N/A	N/A	N/A	821-1A
822-1A	9.0	N/A	0.42-0.56	14.7	11.3	4.7	18.0	210	N/A	N/A	N/A	N/A	822-1A
822-1B	9.0	N/A	0.41-0.52	14.7	11.3	4.7	18.0	210	N/A	N/A	N/A	N/A	822-1B
823-1A	9.0	N/A	0.14-0.23	11.2	N/A	N/A	18.0	110	N/A	N/A	N/A	N/A	823-1A
824-1A	9.0	N/A	0.39-0.62	11.2	N/A	N/A	18.0	210	N/A	N/A	N/A	N/A	824-1A
825-1A	9.0	N/A	0.17-0.34	11.2	N/A	N/A	18.0	110	N/A	N/A	N/A	N/A	825-1A
826-1A	9.0	N/A	0.39-0.54	11.2	N/A	N/A	18.0	210	N/A	N/A	N/A	N/A	826-1A
827-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	827-1A
828-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	828-1A
828-1B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	828-1B
829-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	829-1A
830-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	830-1A
851-1A	9.0	4.5	0.24-0.30	N/A	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	851-1A
852-1A	2.6	1.3	0.23-0.29	N/A	42.0	17.7	18.0	150	N/A	N/A	N/A	N/A	852-1A
853-1A	4.7	2.4	0.24-0.30	N/A	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	853-1A
854-1A	9.0	4.5	0.24-0.30	N/A	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	854-1A
855-1A	9.0	2.9	0.32-0.36	18.0	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	855-1A
856-1A	9.0	3.1	0.31-0.36	18.0	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	856-1A
857-1A	9.0	2.7	0.31-0.35	18.0	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	857-1A
858-1A	9.0	2.5	0.31-0.35	18.0	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	858-1A
859-1A	9.0	2.8	0.30-0.34	18.0	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	859-1A
859-1B	9.0	3.2	0.28-0.32	18.0	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	859-1B
859-1C	9.0	3.0	0.30-0.31	18.0	11.3	4.7	18.0	100	N/A	N/A	N/A	N/A	859-1C
859-1D	9.0	2.8	0.30-0.32	18.0	11.3	4.7	18.0	N/A	N/A	N/A	N/A	N/A	859-1D
860-1A	9.0	2.8	0.30-0.33	12.6	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	860-1A
861-1A	9.0	3.2	0.27-0.32	18.0	11.3	4.7	18.0	150	N/A	N/A	N/A	N/A	861-1A
862-1A	9.0	6.4	0.55-0.64	18.0	11.3	4.7	18.0	210	N/A	N/A	N/A	N/A	862-1A

VST OPERATING CONDITIONS

RUN NO.	ALK TYPE	FLY ASH	MGO	PH CONTR POINT	PRESCRUB VENTURI PH CONTR POINT	GAS RATE ACFM	GAS VEL FPS	VEN LIQ RATE GPM	S.T. LIQ RATE GPM	VEN L/G GAL/ MACF	S.T. L/G GAL/ MACF	SOLID RECIRC NOM %	PRESCRUB VEN NOM % SOLIDS RECIRC	SOLIDS DISCH RANGE %	RUN NO.
863-1A	L	Y	N	7.80	N/A	N/A	N/A	600	1600	N/A	N/A	10.4	N/A	80-89	863-1A
864-1A	L	Y	N	7.80	N/A	35000	9.4	600	1600	21.4	57.0	9.5	N/A	81-88	864-1A
865-1A	L	Y	N	7.80	N/A	35000	9.4	600	1600	21.4	57.0	10.1	N/A	76-84	865-1A
866-1A	L	Y	N	7.80	N/A	35000	9.4	600	1600	21.4	57.0	9.9	N/A	78-84	866-1A
867-1A	L	Y	N	7.80	5.50	35000	9.4	600	1600	21.4	57.0	11.8	15.0	83-88	867-1A

VST OPERATING CONDITIONS (CONTINUED)

RUN NO.	VEN D.P. IN. H2O	S.T. D.P. IN. H2O	M.E.SYSTEM D.P.RANGE IN.H2O	EFFLU RES TIME MIN	SPARGE TANK RESID TIME MIN.	VENTURI DESUP TANK RES TIME MIN.	SPARGE TANK LEVEL FEET	OXID AIR RATE SCFM	EDUCTOR CIRCUL RATE GPM	BLEED TO OX TANK GPM	BLEED OXID TANK PH	H2SO4 RATE GPM	RUN NO.
863-1A	5.6	5.0	0.06-0.61	14.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	863-1A
864-1A	9.0	6.3	0.48-0.68	14.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	864-1A
865-1A	9.0	6.0	0.56-0.78	14.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	865-1A
866-1A	9.0	7.4	0.61-0.75	14.7	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	866-1A
867-1A	9.0	N/A	0.66-0.82	14.7	8.8	4.7	14.0	210	N/A	N/A	N/A	N/A	867-1A

VST ANALYTICAL RUN SUMMARY (GASES)

RUN NO.	AVG SO2 IN PPM	MIN SO2 IN PPM	MAX SO2 IN PPM	AVG SO2 OUT PPM	MIN SO2 OUT PPM	MAX SO2 OUT PPM	AVG SO2 REM %	MIN SO2 REM %	MAX SO2 REM %	AVG MAKE PER PASS MMOL /L	MIN MAKE PER PASS MMOL /L	MAX MAKE PER PASS MMOL /L	AVG O2 IN %	MIN O2 IN %	MAX O2 IN %	AVG NO2 IN PPM	MIN NO2 IN PPM	MAX NO2 IN PPM	AVG BOIL LOAD MEGA WATT	MIN BOIL LOAD MEGA WATT	MAX BOIL LOAD MEGA WATT
VFG-1A	3044	2560	3560	204	40	900	92	67	99	10.5	7.4	13.0	5.6	3.6	8.5	0	N/A	N/A	139	100	150
VFG-1B	2951	2520	3520	709	540	1000	73	68	76	8.0	7.1	9.2	8.9	7.0	12.8	0	N/A	N/A	142	114	150
VFG-1C	2916	2520	3360	738	520	1000	71	67	78	7.8	7.0	8.8	6.0	4.4	11.5	0	N/A	N/A	149	138	156
VFG-1D	3206	2800	3680	324	120	940	88	66	95	6.0	4.3	7.2	5.6	4.0	6.7	0	N/A	N/A	138	94	156
VFG-1E	3168	2760	3600	784	440	1140	72	65	85	9.6	8.1	11.2	6.3	4.3	10.2	0	N/A	N/A	141	80	156
VFG-1F	3329	2400	3840	2233	1520	2760	25	20	48	10.3	8.7	21.7	5.8	4.7	8.1	0	N/A	N/A	152	142	155
VFG-1G	3042	2080	3400	475	100	620	83	79	95	9.3	7.3	10.1	5.1	4.2	5.6	0	N/A	N/A	140	101	153
VFG-1I	3112	2600	3720	600	380	900	78	70	85	9.1	7.9	10.5	5.1	3.4	7.0	0	N/A	N/A	143	101	152
VFG-1P	3184	2400	3880	1019	680	1540	64	56	70	9.9	7.9	11.1	5.8	3.8	7.5	0	N/A	N/A	141	90	150
VFG-1Q	2433	2240	2600	766	620	860	64	62	71	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
601-1A	3742	3480	4040	632	340	860	81	76	90	21.5	20.5	23.2	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
601-1B	3225	2280	3920	133	30	320	95	89	99	21.7	14.4	26.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
601-1C	3130	2480	3860	619	120	920	77	69	96	17.3	13.1	23.7	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
602-1A	2987	2240	3720	426	180	660	84	78	93	17.8	13.0	21.1	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
603-1A	2912	2400	3520	510	340	740	80	76	85	16.6	14.3	19.1	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
604-1A	2813	1840	7400	478	50	1080	81	59	98	9.3	6.1	28.2	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
605-1A	2941	2720	3200	559	200	810	79	70	92	9.5	8.7	10.7	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
606-1A	2730	2160	3120	681	420	880	72	67	79	8.0	6.8	8.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
607-1A	2891	1860	3160	363	60	470	86	83	96	7.3	5.3	8.2	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
608-1A	3083	1320	3900	479	20	1000	83	67	98	7.5	3.8	9.1	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
609-1A	2768	2240	3440	323	100	520	87	82	95	7.1	5.8	8.7	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
610-1A	2746	2040	3720	188	50	520	92	82	97	7.5	5.6	9.6	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
611-1A	3038	2440	3700	44	7	120	98	96	100	8.8	7.1	10.7	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
612-1A	2724	2260	3120	588	130	1720	76	33	94	6.1	2.6	8.1	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
613-1A	2778	1960	3520	555	320	1060	77	61	88	11.5	8.2	14.7	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
614-1A	2812	2400	3320	394	200	540	84	79	91	12.6	10.8	15.4	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
614-1B	2772	2200	3600	466	280	760	81	73	88	11.9	9.7	15.0	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
615-1A	3020	2720	3680	740	600	1140	73	66	80	11.7	10.1	13.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
615-1B	3038	2680	3760	1365	800	2020	50	40	68	8.1	7.1	10.1	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
616-1A	3314	2800	3720	1362	920	1620	54	47	64	9.6	8.5	11.2	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
617-1A	3356	2520	3920	1326	540	1840	56	47	82	10.0	8.3	14.4	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
618-1A	3428	2600	4040	970	500	1520	68	57	83	9.6	7.9	11.4	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
619-1A	2682	1200	3960	424	35	1060	83	65	98	6.5	3.3	9.1	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
620-1A	3074	2240	3940	496	150	740	82	76	93	7.4	6.1	9.4	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
621-1A	2484	2000	3440	306	170	650	87	79	91	6.3	5.3	8.0	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
622-1A	3020	2120	3840	563	230	1050	79	66	89	7.1	5.5	9.4	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
623-1A	3067	2240	3740	492	210	800	82	75	90	7.4	5.9	9.4	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
624-1A	3165	2200	4000	704	275	1250	75	62	88	8.4	6.7	10.6	N/A	N/A	N/A	0	N/A	N/A	54	54	54
625-1A	2758	2000	3200	547	80	960	78	67	96	7.6	6.0	9.4	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
626-1A	2789	1440	3680	557	80	960	78	67	94	8.1	4.6	9.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
627-1A	2517	1280	3840	418	30	1240	84	64	98	7.6	4.1	11.6	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
628-1A	2833	1120	4040	474	20	1170	83	67	98	6.7	3.0	9.1	N/A	N/A	N/A	0	N/A	N/A	5	5	5
628-1B	3009	1600	3860	448	50	980	84	72	97	7.3	4.2	9.2	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
629-1A	3244	2320	4280	625	180	1050	78	69	95	9.5	7.0	13.2	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A

VST ANALYTICAL RUN SUMMARY (GASES)

RUN NO.	AVG SO2 IN PPM	MIN SO2 IN PPM	MAX SO2 IN PPM	AVG SO2 OUT PPM	MIN SO2 OUT PPM	MAX SO2 OUT PPM	AVG SO2 REM %	MIN SO2 REM %	MAX SO2 REM %	AVG MAKE PER PASS MMOL /L	MIN MAKE PER PASS MMOL /L	MAX MAKE PER PASS MMOL /L	AVG O2 IN %	MIN O2 IN %	MAX O2 IN %	AVG NO2 IN PPM	MIN NO2 IN PPM	MAX NO2 IN PPM	AVG BOIL LOAD MEGA WATT	MIN BOIL LOAD MEGA WATT	MAX BOIL LOAD MEGA WATT
630-1A	3101	2120	3880	219	50	440	91	85	99	10.6	7.1	14.1	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
631-1A	2920	2240	3920	753	200	1600	71	55	93	11.9	9.7	17.4	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
632-1A	2766	2040	3360	481	140	1020	80	64	93	10.8	8.7	13.0	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
633-1A	2993	2200	3600	219	60	560	91	82	98	9.5	6.9	11.0	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
634-1A	2517	1480	3760	558	220	1020	76	68	85	7.0	4.6	9.7	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
635-1A	2602	1700	3600	512	130	1300	79	60	92	7.5	5.8	8.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
636-1A	2955	2320	3560	412	220	740	84	77	89	6.6	5.5	7.8	8.7	7.8	9.5	0	N/A	N/A	139	113	149
637-1A	2998	2680	3520	792	540	1040	70	66	78	7.9	7.3	8.8	7.5	6.0	9.0	0	N/A	N/A	144	128	148
638-1A	2604	2000	3100	523	220	760	78	73	88	7.5	6.3	8.4	8.0	6.3	10.5	0	N/A	N/A	140	100	150
639-1A	2688	2080	3200	346	0	800	86	72	100	8.5	6.9	10.3	8.3	6.4	9.2	0	N/A	N/A	139	103	148
640-1A	2972	2560	3600	560	320	800	79	74	86	8.7	7.9	11.0	7.9	6.5	10.2	0	N/A	N/A	134	105	148
641-1A	2647	2200	3000	293	80	800	87	69	97	11.2	8.1	13.7	9.5	6.0	10.2	0	N/A	N/A	136	100	163
642-1A	2597	2200	3240	706	120	1020	70	61	94	11.3	9.4	16.3	8.1	4.2	12.5	0	N/A	N/A	142	115	149
643-1A	2556	2000	2920	64	20	320	97	88	99	9.2	7.2	10.6	8.6	6.2	10.0	0	N/A	N/A	139	110	148
701-1A	2928	2440	3160	327	220	400	87	85	91	8.7	7.4	9.4	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
702-1A	3058	2760	4060	404	200	840	85	77	92	9.7	9.1	11.6	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
703-1A	3069	2120	4220	1171	720	1820	57	47	68	6.6	4.4	8.5	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
704-1A	3407	2560	4400	438	320	600	85	78	90	10.8	7.8	14.1	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
705-1A	3192	2480	3960	510	260	780	82	72	89	9.3	7.4	11.6	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
706-1A	3146	2480	3840	1029	480	1480	63	53	83	7.4	4.9	10.6	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
707-1A	3576	2680	4400	656	400	1120	79	68	84	10.6	8.1	13.0	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
708-1A	3275	2320	4150	770	320	1480	74	60	87	9.0	6.9	11.4	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
709-1A	3566	2860	4470	659	400	1040	79	70	85	10.5	8.6	13.1	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
710-1A	3328	2280	4000	405	100	780	86	77	96	10.7	7.6	12.6	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
711-1A	3117	2520	3840	557	340	960	80	71	87	9.3	7.5	11.7	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
711-1B	2954	2460	3640	526	380	840	80	72	83	8.8	7.6	10.0	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
712-1A	3216	2560	3880	384	240	600	86	83	91	10.3	8.1	11.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
712-1B	2980	2600	3400	220	100	500	92	84	96	10.2	9.2	11.0	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
713-1A	2987	2680	3600	700	500	840	73	68	81	8.2	7.2	10.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
714-1A	2935	2240	3880	270	70	720	89	78	98	9.8	7.6	13.7	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
715-1A	3566	3200	3720	2242	2100	2360	29	22	33	13.0	8.8	14.7	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
716-1A	3540	3240	3800	2840	2480	3160	11	3	17	4.8	1.1	7.3	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
717-1A	3096	2660	3640	363	100	850	87	71	96	10.0	8.4	11.8	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
718-1A	2411	2120	2680	532	360	800	75	66	82	6.8	6.2	7.2	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
801-1A	3481	2780	3920	1177	820	1680	62	52	74	6.8	5.3	7.9	6.1	4.0	8.5	N/A	N/A	N/A	143	100	165
801-2A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
802-1A	3439	2780	4060	1142	630	1800	63	50	78	6.4	5.2	7.8	6.2	4.5	8.5	N/A	N/A	N/A	143	100	152
803-1A	3145	2640	3520	999	620	1900	64	37	77	5.4	3.3	6.4	6.6	5.3	7.8	N/A	N/A	N/A	131	93	164
804-1A	3221	2460	3840	861	500	1180	70	64	80	6.0	4.7	7.8	7.1	6.1	9.5	N/A	N/A	N/A	139	92	153
805-1A	3426	3000	4130	702	430	1000	77	69	84	7.0	5.7	8.4	6.3	3.8	7.7	N/A	N/A	N/A	147	125	151
806-1A	3340	3000	3840	816	660	1000	73	70	77	6.4	5.5	7.2	5.3	5.0	6.0	N/A	N/A	N/A	132	50	160
806-1B	2820	2520	3320	658	540	880	74	71	77	5.5	5.0	6.2	5.4	4.2	6.6	N/A	N/A	N/A	136	100	150
806-1C	3236	3000	3480	771	660	840	73	70	76	6.3	5.8	6.8	5.9	4.8	6.8	N/A	N/A	N/A	148	148	150
806-1D	3103	2700	3320	583	460	680	79	77	82	6.5	5.6	7.1	6.2	6.0	6.7	N/A	N/A	N/A	144	124	150

VST ANALYTICAL RUN SUMMARY (GASES)

RUN NO.	AVG SO2 IN PPM	MIN SO2 IN PPM	MAX SO2 IN PPM	AVG SO2 OUT PPM	MIN SO2 OUT PPM	MAX SO2 OUT PPM	AVG SO2 REM %	MIN SO2 REM %	MAX SO2 REM %	AVG MAKE PER PASS MMOL /L	MIN MAKE PER PASS MMOL /L	MAX MAKE PER PASS MMOL /L	AVG O2 IN %	MIN O2 IN %	MAX O2 IN %	AVG NO2 IN PPM	MIN NO2 IN PPM	MAX NO2 IN PPM	AVG BOIL LOAD MEGA WATT	MIN BOIL LOAD MEGA WATT	MAX BOIL LOAD MEGA WATT
807-1A	3348	2920	3720	651	400	780	78	75	82	7.0	6.3	7.7	6.1	4.2	8.3	N/A	N/A	N/A	134	110	149
808-1A	2831	2640	3080	601	480	840	76	67	81	5.7	5.0	6.3	8.2	5.3	19.2	N/A	N/A	N/A	144	120	152
809-1A	2435	2060	2720	416	250	520	81	76	87	5.2	4.7	5.7	9.1	6.2	10.5	N/A	N/A	N/A	137	88	154
810-1A	2657	1840	3480	424	160	660	82	75	90	5.8	4.4	7.6	7.7	5.8	8.8	N/A	N/A	N/A	117	94	155
811-1A	2570	2200	3240	377	180	700	83	75	92	5.7	5.0	6.9	8.5	7.5	10.6	N/A	N/A	N/A	126	94	154
812-1A	2341	1960	2900	172	90	300	92	88	95	5.7	4.9	6.8	7.5	6.7	8.8	N/A	N/A	N/A	143	100	153
813-1A	2520	2520	2520	220	220	220	90	90	90	N/A	N/A	N/A	7.3	7.3	7.3	N/A	N/A	N/A	152	152	152
814-1A	2401	1920	2640	198	80	400	91	83	95	5.8	4.9	6.4	7.3	6.0	8.5	N/A	N/A	N/A	122	92	152
815-1A	2493	1860	3260	307	120	540	86	75	93	8.0	6.2	9.9	8.4	7.2	10.6	N/A	N/A	N/A	143	95	156
816-1A	2352	1980	2760	330	200	680	84	72	89	7.4	6.0	8.8	8.8	8.0	10.8	N/A	N/A	N/A	136	95	154
817-1A	2478	1920	3080	403	200	640	82	76	88	7.5	6.3	8.8	6.9	5.5	8.9	N/A	N/A	N/A	130	82	151
818-1A	2594	1840	3080	340	160	470	85	81	91	7.5	5.5	8.8	6.5	5.0	7.8	N/A	N/A	N/A	144	108	154
819-1A	2996	2320	3600	408	160	660	84	77	93	N/A	N/A	N/A	7.3	2.4	9.0	N/A	N/A	N/A	144	103	156
819-1B	2977	2680	3280	427	150	580	84	79	94	N/A	N/A	N/A	8.5	6.5	10.0	N/A	N/A	N/A	143	106	155
820-1A	2279	1280	3240	80	10	520	96	82	99	7.4	4.2	10.5	7.2	6.0	8.3	N/A	N/A	N/A	130	74	158
820-1B	2412	1760	2920	148	60	280	93	89	96	7.6	5.7	9.2	6.5	5.7	9.0	N/A	N/A	N/A	130	50	154
820-1C	2820	2320	3520	256	100	450	89	83	96	8.6	7.5	11.1	6.7	5.0	9.9	N/A	N/A	N/A	136	96	155
821-1A	1720	1720	1720	1340	1340	1340	14	14	14	N/A	N/A	N/A	6.0	6.0	6.0	N/A	N/A	N/A	126	126	126
822-1A	2758	2360	3300	259	40	600	89	80	98	8.3	7.3	9.8	6.6	5.6	10.0	N/A	N/A	N/A	147	96	158
822-1B	2378	1920	2840	220	80	320	89	86	95	7.2	6.2	8.4	7.4	5.0	10.0	N/A	N/A	N/A	139	102	158
823-1A	2507	2320	2960	139	20	240	93	91	99	4.1	3.8	4.7	8.2	6.4	10.0	N/A	N/A	N/A	112	102	138
824-1A	2627	2320	2840	285	120	540	87	78	95	7.8	6.7	8.9	7.3	6.0	10.0	N/A	N/A	N/A	138	96	154
825-1A	2458	1400	2860	135	30	300	93	87	99	4.0	2.4	4.7	8.5	6.0	10.0	N/A	N/A	N/A	139	93	154
826-1A	2731	2000	3240	272	90	560	89	79	95	6.2	4.9	7.4	8.8	7.0	10.0	N/A	N/A	N/A	139	94	157
827-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
828-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
828-1B	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
829-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
830-1A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
851-1A	3267	2920	3840	676	440	960	77	72	83	11.1	10.6	12.3	5.9	5.2	6.7	N/A	N/A	N/A	131	50	152
852-1A	3328	2960	3720	904	540	1200	70	61	80	7.9	6.8	9.1	5.5	4.0	8.2	N/A	N/A	N/A	135	93	159
853-1A	3430	2640	3920	720	380	920	76	73	84	7.0	5.9	7.7	5.1	4.0	7.0	N/A	N/A	N/A	136	59	156
854-1A	3215	2680	3680	531	240	880	81	73	90	7.0	6.4	7.7	5.3	4.5	6.1	N/A	N/A	N/A	146	120	150
855-1A	2370	1480	3080	384	120	640	82	77	91	5.2	3.6	6.3	10.8	9.5	11.5	N/A	N/A	N/A	104	95	112
856-1A	2515	2240	2880	302	180	460	86	79	92	5.8	5.2	6.6	9.5	7.8	15.1	N/A	N/A	N/A	136	105	152
857-1A	2662	2480	2840	391	280	480	83	81	88	5.9	5.4	6.2	9.1	8.0	11.5	N/A	N/A	N/A	134	10	151
858-1A	2773	2360	3100	432	280	560	82	80	88	6.1	5.3	6.7	6.8	5.2	8.1	N/A	N/A	N/A	142	115	154
859-1A	2964	2760	3240	223	130	440	91	85	95	7.2	6.8	7.7	7.8	7.0	8.6	N/A	N/A	N/A	137	98	152
859-1B	2720	2560	3000	222	180	280	91	90	92	6.6	6.3	7.1	10.3	9.5	11.1	N/A	N/A	N/A	112	86	153
859-1C	2656	2320	3360	198	110	440	91	85	95	6.5	5.7	7.6	9.0	8.0	10.3	N/A	N/A	N/A	130	97	150
859-1D	2693	2480	3040	233	140	320	90	87	94	6.5	6.2	7.2	8.1	7.0	9.2	N/A	N/A	N/A	142	125	152
860-1A	2265	1960	2700	120	80	200	94	92	96	5.7	5.0	6.6	8.4	7.5	10.5	N/A	N/A	N/A	133	92	153
861-1A	2708	2080	3200	215	90	440	91	85	96	6.6	5.2	7.7	8.6	8.0	9.8	N/A	N/A	N/A	133	99	154
862-1A	2637	2080	3080	385	180	640	84	77	92	8.2	6.5	9.4	7.6	5.5	9.1	N/A	N/A	N/A	139	105	154

VST ANALYTICAL RUN SUMMARY (GASES)

RUN NO.	AVG SO2 IN PPM	MIN SO2 IN PPM	MAX SO2 IN PPM	AVG SO2 OUT PPM	MIN SO2 OUT PPM	MAX SO2 OUT PPM	AVG SO2 REM %	MIN SO2 REM %	MAX SO2 REM %	AVG MAKE PER PASS MMOL /L	MIN MAKE PER PASS MMOL /L	MAX MAKE PER PASS MMOL /L	AVG O2 IN %	MIN O2 IN %	MAX O2 IN %	AVG NO2 IN PPM	MIN NO2 IN PPM	MAX NO2 IN PPM	AVG BOIL LOAD MEGA WATT	MIN BOIL LOAD MEGA WATT	MAX BOIL LOAD MEGA WATT
863-1A	2902	2160	4000	333	20	880	87	71	99	N/A	N/A	N/A	9.1	4.5	12.5	N/A	N/A	N/A	134	8	156
864-1A	2187	1600	2580	106	40	250	94	87	98	7.0	5.2	8.3	N/A	N/A	N/A	N/A	N/A	N/A	96	60	130
865-1A	2280	1400	3040	251	20	620	89	77	99	6.7	4.6	8.3	N/A	N/A	N/A	N/A	N/A	N/A	88	20	156
866-1A	2030	1160	3260	91	10	300	95	89	99	6.5	3.9	10.2	6.7	5.0	8.5	N/A	N/A	N/A	57	52	62
867-1A	2196	840	3320	261	10	680	88	76	99	6.4	2.8	9.2	9.0	8.5	10.0	N/A	N/A	N/A	66	65	68

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

RUN NO.	ANALYTICAL POINT	CA++			MG++			SO3=			SO4=			CL-		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
VFG-1A	1816	207	67	764	3333	333	4089	994	22	1945	6524	1368	7899	3982	531	4963
VFG-1B	1816	1265	606	2570	352	163	585	62	0	203	1724	1166	2228	1818	265	4526
VFG-1C	1816	2217	2020	2475	565	493	697	104	45	361	1418	882	1803	4326	3811	5229
	1825	2797	2510	3280	641	578	687	807	542	972	1674	1295	2111	4475	4254	4697
VFG-1D	1816	1678	1225	2340	572	463	600	59	13	180	720	238	1460	3923	3545	4431
	1825	1690	1260	2230	575	466	614	248	45	723	762	164	1743	3951	3634	4343
VFG-1E	1816	1637	1270	2060	531	400	665	80	22	135	729	352	1326	3537	3102	4343
	1825	1777	1330	2230	561	467	695	695	294	1289	911	369	1507	3552	2836	4343
VFG-1F	1816	2188	1850	2800	538	427	634	74	0	228	1140	649	2150	4285	3722	5672
	1825	2506	2090	3540	573	487	691	1106	0	1447	1350	586	1899	4253	3722	5406
VFG-1G	1816	2278	2050	2650	638	549	737	130	45	203	624	201	1010	4805	4343	5672
	1825	2412	2050	2669	653	569	780	602	180	1040	878	263	1385	4776	4254	5229
VFG-1I	1816	1708	1260	2110	705	635	779	52	22	113	719	475	1204	4248	3811	4786
	1825	1791	1415	2120	718	625	777	530	226	814	1051	614	1607	4137	3634	4875
VFG-1P	1816	1560	1350	1840	695	529	1065	68	22	135	1108	723	1622	3730	3013	4077
	1825	1803	1570	2145	704	527	1047	943	316	1379	1518	728	2017	3743	3190	4343
VFG-1Q	1816	415	264	555	14	8	22	21	0	58	182	140	220	620	443	775
601-1A	1815	682	240	853	79	27	98	7	2	16	215	171	347	1168	440	1440
	1825	325	325	325	32	32	32	7	7	7	346	346	346	460	460	460
601-1B	1815	334	289	402	39	26	45	11	3	23	216	181	276	475	360	620
	1825	467	335	678	46	38	52	45	8	81	168	76	249	666	440	980
601-1C	1815	814	779	853	90	82	98	7	2	16	186	179	192	1373	1280	1440
	1825	733	697	760	78	75	81	35	11	56	261	218	299	1193	1160	1230
602-1A	1815	2325	768	3512	91	19	155	143	16	656	2074	590	5254	3065	1276	3959
	1816															
	1825	2108	1120	2744	103	36	150	538	168	1184	1524	517	2332	2913	1240	3956
603-1A	1815	2829	2300	3287	186	152	215	68	24	136	1654	1534	1763	4688	3758	5318
	1816	2940	2940	2940	117	117	117	176	176	176	1715	1715	1715	4555	4555	4555
	1825	2782	2325	3014	215	147	239	200	56	560	1874	1486	2615	4355	3474	5176
604-1A	1816	3209	1307	4325	382	101	798	81	8	272	1629	665	2502	5647	1914	7658
	1825	3011	2180	3390	252	146	346	352	88	568	2168	1573	2795	4729	3226	5318
605-1A	1816	2188	2085	2345	51	36	74	48	16	80	1488	1192	1965	3048	2907	3190
	1825	2246	2190	2325	53	40	62	488	416	568	1859	1698	2053	2977	2942	3013
606-1A	1816	1343	1237	1475	123	102	160	54	8	128	1925	1180	2237	1707	1560	2127
607-1A	1816	1712	1592	1895	195	152	306	59	16	152	2001	1542	2440	2458	2056	2907
	1825	1950	1950	1950	230	230	230	648	648	648	2182	2182	2182	2524	2524	2524
608-1A	1816	3039	1975	4539	338	203	525	53	8	152	1731	1141	2249	4907	2978	8627
609-1A	1816	2601	2080	3024	325	266	451	29	8	64	1420	1210	1689	4160	3970	4325
610-1A	1816	3417	2635	3920	126	24	285	78	24	200	1188	796	1596	5558	4821	6098
611-1A	1816	262	50	498	4097	2980	6600	1613	320	5488	10906	7419	14245	3187	2269	4396
612-1A	1816	610	610	610	3449	3449	3449	352	352	352	12225	12225	12225	3545	3545	3545
618-1A	1815	1752	1250	2255	84	66	103	28	24	32	2435	1441	3430	1400	1170	1630
	1816	1136	1060	1250	79	66	89	20	6	32	2070	1441	2477	992	567	1630

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PH			TOTAL IONS, PPM			PERCENT GYPSUM SATURATION			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
VFG-1A	1816	6.96	6.45	7.07	15119	2512	18076	21	7	87	4.2	-10.1	13.6
VFG-1B	1816	7.99	7.79	8.21	5268	2501	9580	94	51	128	4.9	-10.2	14.6
VFG-1C	1816	8.00	7.86	8.17	8731	7656	9666	89	56	115	3.6	-7.2	14.3
	1825	4.76	4.62	4.95	10514	9709	11244	110	85	134	7.1	0.3	14.6
VFG-1D	1816	7.96	7.87	8.08	7086	6007	8777	42	13	94	5.7	-9.7	12.9
	1825	5.24	4.87	5.58	7366	6190	9530	45	10	109	1.9	-10.1	12.5
VFG-1E	1816	8.02	7.83	8.16	6653	5367	7585	42	21	74	9.7	0.8	15.0
	1825	4.85	4.29	5.20	7635	6250	9121	54	21	88	1.8	-7.7	11.6
VFG-1F	1816	7.93	7.82	8.00	8401	7348	10223	73	45	126	7.9	-1.5	14.6
	1825	4.59	4.35	4.79	9971	8637	12775	88	40	131	0.9	-6.9	14.9
VFG-1G	1816	7.97	7.73	8.29	8655	8268	9532	39	13	65	11.6	3.6	15.0
	1825	5.03	4.81	5.45	9504	8809	10425	55	18	89	6.4	-2.7	13.9
VFG-1I	1816	7.99	7.86	8.25	7609	6588	8955	39	25	71	8.6	2.2	14.7
	1825	4.84	4.53	5.12	8406	7671	9668	57	34	93	1.2	-13.6	10.5
VFG-1P	1816	7.94	7.49	8.14	7311	6011	8094	57	37	87	6.8	-16.9	14.2
	1825	4.72	4.50	4.91	8862	7517	9547	81	43	109	-5.6	-17.8	11.9
VFG-1Q	1816	8.02	7.79	8.50	1295	939	1579	14	11	18	5.8	-7.1	14.6
601-1A	1815	8.04	7.85	8.40	2155	884	2535	15	12	25	4.5	-12.7	18.1
	1825	5.20	5.20	5.20	1172	1172	1172	24	24	24	-7.5	-7.5	-7.5
601-1B	1815	8.21	8.10	8.30	1106	916	1353	15	13	20	8.5	1.4	17.1
	1825	5.16	4.60	5.45	1389	1082	1853	12	6	18	13.7	7.1	20.0
601-1C	1815	7.95	7.85	8.10	2475	2427	2535	14	13	15	11.2	7.4	18.1
	1825	5.07	4.90	5.30	2304	2234	2339	19	16	23	7.2	3.8	10.3
602-1A	1815	8.00	7.55	8.70	7930	2805	13224	164	48	402	-2.9	-15.0	11.5
	1816												
	1825	5.25	4.90	5.70	7403	4190	9907	119	43	186	-6.6	-15.3	0.0
603-1A	1815	8.05	8.00	8.10	9840	8232	10880	132	119	140	0.2	-2.1	3.0
	1816	8.20	8.20	8.20	9825	9825	9825	143	143	143	-1.6	-1.6	-1.6
	1825	5.43	4.85	7.80	9762	8574	10815	146	118	196	-0.1	-12.6	13.7
604-1A	1816	7.96	5.30	9.30	11295	4540	14368	123	52	183	2.8	-15.6	18.7
	1825	6.00	4.95	8.90	10914	7553	12217	167	123	204	-2.7	-11.3	3.6
605-1A	1816	9.02	8.90	9.10	7065	6518	7343	123	101	159	2.0	-5.8	6.2
	1825	5.00	4.90	5.10	7852	7740	8051	152	139	169	-9.4	-11.0	-8.4
606-1A	1816	8.00	7.80	8.30	5304	4457	5806	132	84	153	-10.0	-18.2	18.9
607-1A	1816	8.09	7.80	8.30	6589	6058	7269	139	112	168	-5.9	-11.4	3.4
	1825	5.10	5.10	5.10	7753	7753	7753	153	153	153	-8.2	-8.2	-8.2
608-1A	1816	8.05	7.65	8.40	10382	7385	15504	129	99	161	5.9	-14.5	17.5
609-1A	1816	5.00	5.00	5.00	8723	7890	9381	105	80	131	8.5	-4.3	15.6
610-1A	1816				10595	9535	11279	100	74	130	2.3	-5.7	5.8
611-1A	1816	7.05	6.90	7.30	20208	16133	28310	37	5	79	-2.8	-18.4	17.1
612-1A	1816	7.04	7.04	7.04	20181	20181	20181	94	94	94	-15.6	-15.6	-15.6
618-1A	1815	8.40	8.40	8.40	5780	4486	7075	180	108	253	2.9	-9.2	15.0
	1816				4377	4113	4532	139	108	161	-8.9	-14.2	-3.2

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

RUN NO.	ANALYTICAL POINT	CA++			MG++			SO3=			SO4=			CL-		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
618-1A	1825	1651	1565	1737	86	85	88	1005	912	1099	118[illegible]	513	1862	1134	709	1560
619-1A	1816	1943	1505	2277	246	109	355	107	16	384	192[illegible]	907	3397	3018	2623	3613
	1825	2045	1685	2518	292	131	418	680	456	816	235[illegible]	2098	2565	2956	2694	3432
620-1A	1815	1440	1440	1440	200	200	200	22	22	22	1830	1830	1830	2202	2202	2202
	1816	1602	1440	1765	218	200	237	63	22	104	1891	1829	1953	2129	2056	2202
	1825	1590	1575	1605	377	206	549	479	454	504	1616	950	2283	2109	1985	2233
621-1A	1816	1750	1750	1750	169	169	169	28	28	28	1841	1841	1841	2535	2535	2535
622-1A	1816	2378	1935	2810	260	45	339	71	8	544	1609	1015	2578	3758	2481	4538
	1825	2632	2275	3215	275	219	328	746	352	1272	1820	1213	2337	3859	3368	4467
623-1A	1816	2350	2055	2680	232	186	292	65	16	176	1351	1020	1672	3470	3155	3793
	1825	2714	2709	2719	286	275	298	520	352	688	1828	1817	1840	3775	3687	3864
624-1A	1816	2395	1690	3360	229	61	380	65	8	176	1190	493	1759	3972	2659	5495
	1825	2611	2050	3644	260	125	467	807	664	968	1454	695	2002	4044	2552	5495
625-1A	1816	3038	1215	4280	146	65	216	76	16	144	1368	917	2258	4582	1311	6209
	1825	3433	3090	4160	147	32	199	489	248	736	1762	1264	2295	4939	3864	5850
626-1A	1816	2808	2150	4000	225	165	270	76	16	312	1307	633	2072	4772	3687	6523
	1825	3043	2589	3680	215	173	244	741	440	992	1490	596	2121	4720	4183	5282
627-1A	1816	2490	2076	3186	93	51	190	60	8	208	717	181	1199	4248	3368	5318
	1825	2630	2630	2630	92	92	92	40	40	40	617	617	617	4644	4644	4644
628-1A	1816	1958	1115	2859	271	115	364	75	4	328	1434	749	2350	3340	1595	4254
	1825	2108	1485	3110	262	138	339	393	58	760	1995	1194	2568	3149	2517	3935
628-1B	1816	2357	1755	3370	297	227	382	47	0	144	1180	793	1940	4199	3226	5548
	1825	2334	1965	2574	322	302	347	626	544	672	1310	1036	1509	4019	3474	4715
629-1A	1816	644	223	924	3771	2809	5349	849	90	2216	9763	6803	13619	3887	3013	5140
630-1A	1816	268	106	600	3923	3179	4949	633	180	1492	7610	5910	10220	5636	4609	6381
631-1A	1816	585	106	1182	4560	3539	5889	482	113	1221	8102	5806	9446	7428	5672	9218
632-1A	1816	229	141	461	4589	4009	5459	783	316	1402	7252	5543	8193	7119	6381	8509
633-1A	1816	177	83	569	4067	3579	4649	1124	271	2103	8205	6055	9496	5051	4431	5850
634-1A	1816	1950	1356	2530	332	28	587	66	13	226	1370	261	2994	3408	1950	4343
635-1A	1816	2260	1890	2679	639	515	753	97	36	226	1494	339	2442	4627	4077	5300
636-1A	1816	2140	1490	2690	650	597	689	75	22	226	1422	499	2072	4282	3545	4963
637-1A	1816	1[illegible]12	1200	1975	604	539	700	92	22	316	1469	1125	1740	3368	2747	3722
638-1A	1816	2008	1400	2380	609	491	751	119	22	226	1995	1386	2391	3616	2925	4077
639-1A	1816	602	37	1233	3301	2759	4139	671	81	3121	8251	4591	10214	3363	2304	4431
640-1A	1816	714	459	986	3126	2809	3639	181	45	407	7903	6996	9049	3699	3013	4520
641-1A	1816	171	61	840	3702	3319	4069	1372	316	1922	8827	6250	7987	4788	3994	6381
642-1A	1816	444	79	1178	4001	3490	4459	553	135	1786	8164	5965	10549	5798	4526	7622
	1825	2090	2090	2090	163	163	163	760	760	760	880	880	880	2942	2942	2942
643-1A	1816	122	76	282	3700	3159	4389	1064	474	1470	6765	4779	9115	4669	3545	6027
701-1A	1816	2232	1940	2579	437	392	465	41	8	72	440	329	596	4935	4857	5034
	1825	2985	2985	2985	459	459	459	64	64	64	752	752	752	4928	4928	4928
702-1A	1816	1943	1630	2110	529	447	634	61	32	88	411	278	520	4735	4360	5176
	1825	1910	1910	1910	518	518	518	24	24	24	383	383	383	4573	4573	4573

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PH AVG	PH MIN	PH MAX	TOTAL IONS, PPM AVG	TOTAL IONS, PPM MIN	TOTAL IONS, PPM MAX	PERCENT GYPSUM SATURATION AVG	PERCENT GYPSUM SATURATION MIN	PERCENT GYPSUM SATURATION MAX	PERCENT IONIC IMBALANCE AVG	PERCENT IONIC IMBALANCE MIN	PERCENT IONIC IMBALANCE MAX
618-1A	1825	4.88	4.85	4.90	5141	5079	5203	91	43	139	10.8	6.7	14.8
619-1A	1816	7.76	7.40	8.10	7404	6668	8853	134	65	247	-4.9	-19.5	10.9
	1825	5.05	4.90	5.20	8486	7787	9114	157	141	166	-14.0	-17.5	-11.6
620-1A	1815	8.00	8.00	8.00	5812	5812	5812	122	122	122	-9.5	-9.5	-9.5
	1816				6036	5811	6261	128	122	134	0.1	-9.5	9.6
	1825	5.15	5.00	5.30	6290	5535	7045	96	69	123	7.5	5.1	9.9
621-1A	1816				6448	6448	6448	133	133	133	-5.1	-5.1	-5.1
622-1A	1816	7.73	4.60	8.70	8240	6481	10076	119	81	181	2.6	-12.3	15.7
	1825	5.03	4.65	5.30	9513	8504	10441	136	96	178	-3.8	-12.5	11.2
623-1A	1816	7.99	7.20	8.60	7650	6896	8442	103	80	125	10.0	2.6	16.6
	1825	5.03	4.90	5.15	9301	9065	9538	138	138	138	4.2	-0.2	8.6
624-1A	1816	8.02	7.20	8.40	8038	5836	11055	91	41	135	3.5	-9.3	18.2
	1825	4.93	4.60	5.20	9345	6957	12094	111	57	153	-5.0	-18.9	17.5
625-1A	1816	8.15	7.45	9.00	9382	4001	12394	113	80	181	5.0	-8.2	17.8
	1825	4.80	4.55	5.35	10943	9611	12610	148	106	185	-0.3	-7.1	7.8
626-1A	1816	8.02	7.55	8.30	9375	7414	12483	104	51	159	0.1	-11.3	19.4
	1825	4.67	4.40	5.00	10390	9525	11631	118	52	163	-5.5	-19.9	11.5
627-1A	1816	8.07	7.80	8.25	7843	6381	9730	61	16	103	2.1	-6.3	9.5
	1825	5.50	5.50	5.50	8274	8274	8274	54	54	54	1.2	1.2	1.2
628-1A	1816	7.56	6.30	8.55	7285	5218	8965	100	46	167	-0.2	-18.8	17.3
	1825	5.00	4.59	5.40	8108	6343	9855	141	76	194	-5.9	-15.7	10.5
628-1B	1816	7.80	6.90	8.30	8270	6663	11081	87	57	148	2.2	-15.4	17.2
	1825	4.95	4.90	5.00	8825	8079	9424	94	76	105	-5.2	-13.9	7.0
629-1A	1816	5.98	5.64	6.15	19046	15517	24621	76	28	114	3.3	-8.5	12.2
630-1A	1816	6.94	6.17	7.12	18238	15864	20750	27	11	77	1.7	-15.3	19.7
631-1A	1816	6.98	6.79	7.12	21287	16491	25544	53	9	110	4.4	-8.6	11.4
632-1A	1816	6.98	6.45	7.36	20115	18721	22450	19	9	41	5.4	-3.0	15.6
633-1A	1816	7.03	6.86	7.28	18763	16992	20703	18	7	60	1.6	-14.4	11.4
634-1A	1816	8.01	7.66	8.16	7157	4301	9836	93	18	184	-1.1	-18.9	17.3
635-1A	1816	8.02	6.32	8.65	9162	7567	10476	91	21	148	1.6	-9.2	11.9
636-1A	1816	8.01	7.79	8.24	8613	6689	10045	86	27	132	5.7	-1.0	16.9
637-1A	1816	7.92	6.57	8.79	7180	5888	8190	79	59	102	2.4	-7.6	8.7
638-1A	1816	7.95	7.69	8.20	8383	6457	9091	115	76	138	2.8	-6.5	14.3
639-1A	1816	6.99	6.91	7.19	16214	12251	17921	71	3	136	6.2	-2.1	14.3
640-1A	1816	7.06	6.87	7.96	15651	14210	17882	80	46	110	6.8	-4.3	14.9
641-1A	1816	7.00	6.75	7.15	16885	15484	18173	15	5	73	0.6	-6.3	6.4
642-1A	1816	6.98	6.55	7.23	18990	16124	22217	46	6	135	1.3	-10.1	9.0
	1825	4.80	4.80	4.80	7044	7044	7044	70	70	70	2.9	2.9	2.9
643-1A	1816	6.96	6.59	7.15	16351	14220	19367	11	5	30	3.8	-8.2	12.6
701-1A	1816	5.86	5.80	5.90	8267	7971	8687	31	23	43	2.1	-6.9	12.8
	1825	5.65	5.65	5.65	9387	9387	9387	56	56	56	18.9	18.9	18.9
702-1A	1816	5.84	5.75	5.95	7826	7033	8436	26	18	35	0.6	-9.4	13.9
	1825	5.10	5.10	5.10	7600	7600	7600	25	25	25	4.7	4.7	4.7

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

RUN NO.	ANALYTICAL POINT	CA++			MG++			SO3=			SO4=			CL-		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
703-1A	1816	3044	2665	3609	626	426	841	114	16	320	1464	988	2084	6207	5247	6878
704-1A	1816	2595	1880	3395	737	527	1053	99	56	160	733	240	1535	5849	4928	6736
705-1A	1816	1473	1000	2185	590	491	657	83	48	136	754	476	1111	3847	3190	4538
706-1A	1816	1805	1465	2295	672	582	757	168	24	376	2370	1390	2745	3871	3580	4290
707-1A	1816	1575	1070	2015	905	777	1082	141	50	264	945	421	1533	4410	4041	4644
708-1A	1816	1680	1220	2140	817	529	924	108	32	240	1181	695	1568	4580	4006	5347
709-1A	1816	1096	565	2045	792	737	875	59	16	112	882	529	1326	3651	3155	4538
710-1A	1816	947	504	2277	774	109	949	87	32	184	784	410	1455	3350	3013	3900
711-1A	1816	1669	1035	2155	646	297	849	96	16	384	1456	905	2039	3726	2623	4821
711-1B	1816	2473	1735	3059	650	355	771	106	72	144	1412	440	1971	5326	2978	6559
712-1A	1816	1613	1060	2749	761	699	800	84	40	176	520	360	825	4935	3900	6594
712-1B	1816															
713-1A	1816	2516	2140	2879	876	783	947	96	88	104	2188	1951	2644	5530	4609	6452
714-1A	1816	611	208	1200	5035	4129	6509	1279	520	3634	14310	9584	18053	5241	3651	6771
715-1A	1816	801	730	872	5569	4759	6379	1864	1304	2425	13377	12544	14210	5761	5424	6098
716-1A	1816	1057	1057	1057	5769	5769	5769	6468	6468	6468	13890	13890	13890	5743	5743	5743
717-1A	1816	622	396	1260	4962	3839	5719	1768	472	3778	15955	11535	20144	3176	1595	5530
718-1A	1816	2386	2100	2810	594	447	711	110	31	316	1870	1670	2277	4519	3722	5229
801-1A	1815	1254	1015	1567	615	420	723	65	11	814	2158	1819	2508	2359	1373	3168
	1816	842	278	1300	350	158	438	221	45	407	1575	768	2428	1118	265	1506
	1825	1075	810	1297	396	364	418	389	260	565	2016	1326	2468	1329	1107	1484
	1851	1483	1310	1667	673	634	722	410	147	588	2535	2106	2809	2773	2282	3257
802-1A	1815	1607	1280	2110	700	586	861	24	0	124	2159	1915	2633	3405	2481	4697
	1816	1308	1025	1610	486	401	609	197	33	508	2229	1904	2627	1979	1240	2747
	1825	1324	1015	1635	483	379	601	273	90	701	2282	1938	2740	1955	1329	2747
	1851	1876	1510	2315	702	503	873	462	45	882	2545	1807	3020	3494	2260	4697
803-1A	1815	2094	1725	2560	784	639	859	24	0	67	1904	1690	2195	4677	3988	5894
	1816	1674	1455	1940	549	455	589	264	90	1334	2257	1916	2914	2839	2659	3190
	1825	1683	1430	2080	534	443	585	333	67	1537	2277	1807	3004	2756	2397	3190
	1851	2264	1920	2695	784	659	853	311	22	531	2334	2078	2697	4728	3611	5827
804-1A	1815	2277	2010	2719	875	587	1011	22	0	90	1928	1711	2513	5360	4121	6204
	1816	1663	1520	1890	582	485	641	132	45	248	1974	1666	2424	3204	2836	3900
	1825	1669	1480	1870	576	519	637	173	79	316	1995	1713	2359	3150	2747	3877
	1851	2453	2190	2920	897	829	971	386	22	836	2298	1937	2788	5529	4742	6293
805-1A	1815	2231	1970	2495	1104	899	1251	13	0	67	1950	1789	2272	6025	5052	6470
	1816	663	374	1480	460	409	561	67	22	180	815	525	1883	1745	1196	2902
	1825	618	378	1385	450	389	565	80	22	226	744	444	1666	1687	1063	2792
	1851	2378	2150	2540	1112	1021	1243	334	45	565	2363	1949	3012	6202	5872	6603
806-1A	1815	2060	1920	2315	1224	1121	1325	16	0	33	2059	1931	2337	5970	5717	6381
	1816	392	335	450	393	367	419	93	33	226	733	434	901	1125	1019	1196
	1825	389	325	440	385	367	407	101	45	135	707	559	906	1070	975	1152
	1851	2203	2025	2490	1232	1111	1313	350	11	497	2330	2101	2573	6108	5850	6603
806-1B	1815	2202	1910	2440	1248	1145	1313	15	0	45	2042	1855	2194	6481	5694	7046

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PH			TOTAL IONS, PPM			PERCENT GYPSUM SATURATION			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
703-1A	1816	5.21	5.08	5.32	11666	10498	12687	100	70	147	0.6	-11.9	14.9
704-1A	1816	5.79	5.58	5.99	10239	8393	12597	48	12	106	7.1	-8.6	15.6
705-1A	1816	5.72	5.35	6.00	6926	5765	8581	41	21	72	0.7	-11.9	13.3
706-1A	1816	5.37	5.10	5.70	9067	7929	9910	125	72	158	-8.3	-18.1	12.2
707-1A	1816	5.76	5.60	5.85	8174	6737	9215	44	17	83	6.9	-1.2	17.7
708-1A	1816	5.65	5.50	5.85	8565	7124	9826	60	29	86	0.7	-6.8	12.4
709-1A	1816	5.85	5.65	5.99	6665	5412	8835	36	16	71	1.6	-9.4	16.6
710-1A	1816	6.01	5.86	6.19	6129	4957	7671	31	11	118	2.9	-8.2	14.6
711-1A	1816	5.65	5.46	5.88	7759	6332	9686	78	44	123	2.1	-17.6	19.4
711-1B	1816	5.58	5.57	5.60	10158	7142	12697	90	27	127	0.2	-3.2	7.8
712-1A	1816	5.80	5.63	6.10	8092	6471	10859	26	16	36	-2.6	-12.4	6.1
712-1B	1816												
713-1A	1816	5.24	5.14	5.36	11393	10549	12546	123	116	136	-0.2	-1.3	1.7
714-1A	1816	5.56	5.33	5.85	26628	19402	30524	84	27	168	-6.4	-19.0	7.2
715-1A	1816	5.43	5.30	5.55	27533	26192	28874	96	84	109	1.9	-7.8	11.6
716-1A	1816	4.98	4.98	4.98	32767	32767	32767	125	125	125	-14.9	-14.9	-14.9
717-1A	1816	5.45	5.03	5.70	26633	23004	30845	92	63	153	-5.6	-18.2	9.3
718-1A	1816	5.91	5.33	6.94	9518	8638	10361	117	106	136	-0,3	-15.9	18.7
801-1A	1815	4.57	3.83	4.95	6552	5337	7375	99	88	126	2.6	-14.5	11.2
	1816	5.76	5.43	6.12	4163	1594	5864	75	30	126	4.4	-3.8	14.4
	1825	5.61	5.19	5.98	5270	4025	6177	101	63	128	-0.4	-12.1	8.3
	1851	3.94	3.43	4.40	8001	7559	8367	120	104	129	-5.7	-9.6	-1.1
802-1A	1815	4.96	4.00	5.33	8046	6493	9720	107	94	138	0.8	-12.3	9.5
	1816	5.55	5.27	5.95	6310	5249	7774	113	92	139	2.0	-12.5	13.4
	1825	5.29	4.20	5.95	6418	5127	7786	117	100	145	-0.2	-13.2	6.7
	1851	4.36	3.96	4.98	9208	7732	10725	133	103	152	-4.8	-14.9	8.1
803-1A	1815	5.09	4.66	5.79	9705	8738	11254	104	96	119	2.3	-11.9	7.8
	1816	5.57	4.66	5.83	7710	7012	9598	124	103	164	-0.5	-14.5	8.0
	1825				7703	6496	9956	126	98	175	-1.1	-14.6	5.4
	1851	4.43	3.79	4.99	10642	9101	11948	130	117	152	-2.6	-14.5	5.8
804-1A	1815	5.07	4.79	5.40	10715	9927	11897	105	93	136	1.2	-9.1	10.6
	1816	5.79	5.12	5.99	7691	7199	8692	107	88	133	0.5	-6.9	5.0
	1825				7703	7044	8734	109	90	133	0.6	-6.8	7.7
	1851	4.43	3.86	4.75	11808	10792	12800	127	111	157	-4.4	-9.9	0.4
805-1A	1815	4.92	4.65	5.28	11636	10079	12312	97	88	107	0.8	-3.6	4.6
	1816	6.06	5.69	6.20	3940	2861	7009	33	18	100	12.9	0.8	19.3
	1825				3762	2745	6650	29	16	86	12.4	4.4	18.3
	1851	4.36	4.04	4.68	12709	12246	12957	119	94	149	-5.3	-7.5	-2.6
806-1A	1815	4.62	4.48	4.79	11667	11300	12139	93	89	102	1.6	-0.3	4.6
	1816	6.16	6.06	6.25	2817	2649	3086	23	12	32	9.8	4.6	12.9
	1825				2731	2573	2904	22	16	31	11.8	6.9	16.6
	1851	3.85	3.54	3.82	12568	12128	13248	109	98	118	-2.9	-6.2	2.1
806-1B	1815	4.53	4.45	4.61	12344	11479	13042	95	91	101	-0.3	-4.9	4.6

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

RUN NO.	ANALYTICAL POINT	CA++			MG++			SO3=			SO4=			CL-		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
806-1B	1816	815	453	706	384	345	409	101	67	180	1423	968	1772	1114	975	1240
	1825	632	459	736	378	350	401	86	11	203	1543	1076	1949	1088	975	1258
	1851	2314	2015	2574	1267	1161	1331	250	0	520	2429	2012	2864	6580	5805	7179
806-1C	1815	1905	1880	1955	1170	1151	1207	15	11	22	2250	2012	2581	5538	5335	5761
	1816	560	360	694	315	213	365	101	56	135	1277	670	1702	970	930	1041
	1825	563	366	721	310	217	359	180	67	452	1192	506	1691	904	886	930
	1851	2044	1975	2135	1189	1167	1231	276	22	441	2604	2285	3020	5569	5406	5938
806-1D	1815	2027	1860	2140	1192	1151	1269	129	11	294	2277	969	2933	5273	4609	5539
	1816	308	293	335	397	367	453	116	90	158	684	548	813	993	930	1196
	1825	304	290	341	376	324	411	107	67	158	664	517	801	974	886	1240
	1851	2252	2100	2360	1204	1145	1273	698	260	949	2601	1522	3319	5469	5140	5717
807-1A	1815	1908	1810	2005	1020	899	1079	553	192	995	2931	2463	3622	4317	3900	4697
	1816	153	137	169	333	324	343	158	124	226	559	349	856	693	531	797
	1825	165	155	175	341	333	349	124	124	124	402	364	441	786	731	842
	1851	2030	1960	2125	1032	973	1101	990	554	1492	3063	2701	3966	4480	4010	4830
808-1A	1815	1566	1415	1715	1114	975	1197	19	0	45	2469	2227	2813	4257	3811	5052
	1816	220	220	220	266	266	266	45	45	45	931	931	931	310	310	310
	1825	210	210	210	266	266	266	45	45	45	973	973	973	310	310	310
	1851	1670	1500	1850	1104	967	1191	325	214	429	2807	2609	3338	4368	3855	5008
809-1A	1815	2830	2095	3489	1294	1087	1459	35	0	101	1834	1668	2004	7147	6204	8509
	1816	1816	1705	1950	711	611	789	98	33	217	2002	1792	2131	3562	3235	3811
	1825	1915	1740	2780	733	630	992	167	67	746	2113	1895	2508	3740	3279	6364
	1851	2857	2385	3799	1283	924	1544	149	0	443	2116	1775	2480	7001	6248	8331
810-1A	1815	1873	1140	2385	1141	977	1342	25	0	88	2171	1836	2652	4952	3900	6260
	1816	1455	1245	1775	639	544	719	88	13	191	2119	1860	2388	2653	2215	3545
	1825	1473	1275	1815	644	537	784	110	33	214	2133	1919	2424	2679	2082	3456
	1851	2039	1620	2584	1145	974	1324	280	113	814	2425	2023	2727	4983	3988	6337
811-1A	1815	1492	1125	1880	1032	567	1169	44	0	113	2551	2134	3074	3601	3190	4298
	1816	1262	1015	1690	594	312	757	108	56	169	2277	2032	2608	2149	1684	2481
	1825	1261	1040	1610	593	309	762	124	67	203	2276	1932	2737	2134	1817	2526
	1851	1558	1090	1955	1044	799	1249	473	243	938	2627	2141	3202	3649	3146	4343
812-1A	1815	1531	1320	1745	1137	1012	1389	67	5	237	2692	2483	2905	4056	3368	4564
	1816	1213	1042	1375	788	607	1012	109	67	147	2518	2300	2806	2528	1950	3057
	1825	1236	1022	1370	788	617	1014	148	67	294	2508	2290	2936	2564	1950	3146
	1851	1668	1430	1950	1133	892	1322	342	22	621	2872	2106	3407	4112	3545	4609
813-1A	1815	1420	1420	1420	1167	1167	1167	50	50	50	2861	2861	2861	4015	4015	4015
	1816	1350	1350	1350	877	877	877	137	137	137	2705	2705	2705	2969	2969	2969
	1825	1320	1320	1320	822	822	822	137	137	137	2603	2603	2603	2836	2836	2836
	1851	1645	1645	1645	1189	1189	1189	525	525	525	3008	3008	3008	4210	4210	4210
814-1A	1815	1524	1370	1790	1386	1027	1509	28	4	67	3000	2549	3348	4442	4121	5273
	1816	1281	1140	1440	866	612	1022	126	73	226	2561	2310	3062	2761	2570	3057
	1825	1241	1065	1375	855	682	992	127	79	248	2596	2311	2990	2720	2481	2947
	1851	1584	1385	1900	1340	1132	1464	332	158	633	3219	2607	3695	4439	4157	5273

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PH			TOTAL IONS, PPM			PERCENT GYPSUM SATURATION			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
806-1B	1816	6.08	5.95	6.24	3706	3122	4140	56	32	77	1.7	-9.3	9.0
	1825				3795	3031	4280	62	37	78	0.5	-9.0	10.3
	1851	3.76	3.58	4.00	13203	12304	13825	115	102	136	-4.3	-8.4	-0.4
806-1C	1815	4.49	4.31	4.57	11238	10906	11708	99	90	113	0.2	-3.9	2.9
	1816	6.01	5.87	6.15	3295	2507	3960	53	21	72	-0.7	-14.7	14.5
	1825				3217	2434	3914	50	24	73	1.5	-12.1	14.5
	1851	3.67	3.36	4.03	12053	11745	12798	117	103	139	-2.6	-8.1	0.4
806-1D	1815	4.53	4.46	4.61	11286	10224	12334	103	45	131	6.4	1.7	14.3
	1816	6.16	6.12	6.20	2574	2388	2823	18	16	22	11.1	7.3	14.0
	1825				2501	2278	2865	18	16	21	9.9	2.6	13.7
	1851	4.23	4.11	4.36	12611	11882	13379	123	74	156	-0.4	-2.9	5.2
807-1A	1815	4.48	4.41	4.57	11101	10336	11749	134	112	165	-2.1	-4.7	3.1
	1816	6.28	6.21	6.35	1969	1838	2148	9	6	14	6.3	-6.5	14.4
	1825				1894	1893	1896	8	7	9	13.3	8.7	17.9
	1851	4.34	4.25	4.49	11986	11661	12744	144	127	183	-7.4	-12.3	-4.7
808-1A	1815	4.53	4.41	4.64	9786	9110	10615	98	92	109	5.9	1.1	14.2
	1816	6.33	6.33	6.33	1850	1850	1850	24	24	24	17.9	17.9	17.9
	1825				1880	1880	1880	24	24	24	14.1	14.1	14.1
	1851	3.56	3.32	3.92	10630	9896	11274	115	108	132	-1.6	-4.0	2.6
809-1A	1815	4.50	4.40	4.69	13318	11831	15322	96	83	116	5.1	-6.1	11.9
	1816	5.72	5.57	5.85	8307	7604	8683	106	95	113	5.6	-3.0	11.8
	1825				8787	7885	13357	113	101	132	4.4	-8.9	10.6
	1851	3.34	2.82	4.09	13587	12480	15963	111	101	127	3.4	-6.1	11.7
810-1A	1815	5.09	4.83	5.73	10321	8806	11987	95	73	109	3.8	-7.3	11.6
	1816	5.81	5.48	5.98	7055	6220	8208	103	93	115	6.0	-5.5	14.0
	1825				7143	6247	8396	104	93	117	5.6	-14.1	14.1
	1851	4.23	3.70	5.07	11037	9799	12701	111	91	131	1.7	-13.3	9.5
811-1A	1815	5.50	5.25	5.74	8868	7795	9458	102	87	146	5.2	-6.6	14.6
	1816	6.02	5.77	8.10	6493	5823	7020	105	90	146	4.0	-13.5	14.5
	1825				6489	5738	7519	106	88	135	3.8	-13.3	14.1
	1851	4.59	3.62	5.06	9513	8660	10417	106	92	125	-0.5	-14.1	13.4
812-1A	1815	5.58	5.15	6.23	9636	8940	10254	104	91	118	1.8	-11.3	12.0
	1816	5.92	5.39	6.05	7263	6204	8015	101	80	119	2.0	-6.2	9.1
	1825				7350	6269	8098	102	80	129	1.6	-4.9	7.1
	1851	4.84	4.43	5.40	10275	9213	11147	116	87	138	-1.6	-13.7	13.5
813-1A	1815	5.91	5.91	5.91	9681	9681	9681	104	104	104	-0.5	-0.5	-0.5
	1816	5.85	5.85	5.85	8157	8157	8157	110	110	110	0.4	0.4	0.4
	1825				7836	7836	7836	108	108	108	0.3	0.3	0.3
	1851	5.25	5.25	5.25	10745	10745	10745	118	118	118	-4.4	-4.4	-4.4
814-1A	1815	5.60	5.32	6.12	10576	9968	11274	104	92	122	4.3	-12.1	12.2
	1816	5.95	5.89	6.19	7715	7297	8274	102	86	131	3.5	-12.5	11.7
	1825	5.88	5.77	6.08	7657	7323	7993	102	85	124	1.8	-8.5	9.7
	1851	4.57	4.04	4.95	11113	10655	11841	115	103	137	-2.1	-10.7	6.3

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

RUN NO.	ANALY TICAL POINT	CA++			MG++			SO3=			SO4=			CL-		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
815-1A	1815	2013	1445	2540	1614	1297	2059	42	5	90	2667	2310	2960	6060	4609	7622
	1816	1565	1240	1835	1095	929	1409	125	0	361	2540	2302	2934	3832	2925	4653
	1825	1609	1245	2035	1091	914	1352	137	45	280	2584	2316	3058	3818	2836	4857
	1851	2165	1660	2599	1560	1224	1904	434	45	746	2881	2019	3453	6010	4520	7401
816-1A	1815	2361	2150	2525	1950	1564	2274	26	11	45	2597	2404	2913	7651	6913	8420
	1816	1767	1610	1850	1173	974	1344	129	90	180	2460	2180	2773	4616	4254	4919
	1825	1790	1620	1975	1199	1074	1377	147	101	260	2422	1432	2890	4628	4254	4963
	1851	2475	2245	2705	1933	1764	2144	349	158	508	2861	2483	3298	7665	6825	8376
817-1A	1815	3332	2970	3560	1560	1374	1934	24	0	45	1945	1747	2109	8701	8261	9041
	1816	1970	1680	2180	831	719	947	92	45	226	1874	1525	2133	4391	3900	4830
	1825	1984	1725	2220	795	687	867	95	33	180	1948	1753	2797	4404	3767	4963
	1851	3560	3199	3939	1574	1339	1814	284	79	520	2418	1876	2877	8839	8509	9306
818-1A	1815	3616	2980	4300	1774	1499	1994	28	4	67	2010	1715	2174	9452	8243	10769
	1816	2071	1900	2340	903	812	989	100	39	158	1942	1765	2120	4838	4387	5406
	1825	2084	1895	2275	914	827	972	120	67	203	1931	1545	2172	4876	4405	5247
	1851	3836	3230	4500	1745	1399	1949	312	45	610	2447	1900	2883	9579	8154	10725
819-1A	1815	3521	2460	4509	2275	1659	2854	27	0	90	2183	1844	2484	10892	8509	13118
	1816	2202	1700	2975	1241	782	1644	110	45	203	2126	1738	2710	6150	5008	8110
	1825	2215	1670	3029	1239	719	1637	123	33	214	2157	1712	2623	6135	4875	8420
	1851	3722	2700	5110	2290	1664	2844	353	11	701	2497	1591	3037	10993	8863	13251
819-1B	1815	3475	2729	4490	2455	2324	2629	25	11	56	2446	2180	2576	10432	9395	11434
	1816	2356	1985	2825	1361	1212	1502	118	67	169	2352	2157	2619	6045	5495	6913
	1825	2338	2000	2749	1332	1182	1497	126	22	226	2416	2170	2795	5963	5362	6913
	1851	3704	3009	4509	2460	2194	2704	325	135	520	2845	2440	3184	10480	8863	11966
820-1A	1815	617	522	902	9422	8119	11539	50	11	226	35289	28208	43308	2765	1861	3634
	1816	569	156	786	5551	3879	6559	1435	554	4387	20131	13972	25842	1384	709	1684
	1825	569	274	930	4046	2929	5719	1228	260	3912	14624	8120	21396	1698	1019	2082
	1851	672	561	802	9315	7979	11119	429	45	1040	35350	31121	43672	2769	1817	3589
820-1B	1815	705	646	880	9425	8499	10239	950	33	1877	31530	28391	34224	4168	2836	6293
	1816	638	508	922	5566	4459	6369	1419	780	2259	18596	15815	20255	1830	1373	2836
	1851	761	698	912	9279	7599	10199	1584	407	2962	31232	27811	34078	4237	2747	6337
820-1C	1815	941	820	1214	9294	8159	10059	5583	4466	6672	26473	23859	30382	4435	3988	5052
	1816	613	234	974	5534	4989	6319	1559	972	2307	16871	14258	18843	2352	2041	2570
	1825	627	285	992	5459	4969	6039	1809	1108	3573	16765	13518	18894	2352	2041	2526
	1851	978	894	1204	9217	7939	10019	6275	4862	7633	26277	23982	29257	4753	4254	7223
821-1A	1815	674	674	674	9599	9599	9599	113	113	113	29452	29452	29452	6647	6647	6647
	1825	554	554	554	2980	2980	2980	283	283	283	11617	11617	11617	1553	1553	1553
	1851	724	724	724	9639	9639	9639	1130	1130	1130	29262	29262	29262	6603	6603	6603
822-1A	1815	713	588	832	10466	9460	11640	735	57	4207	31348	26732	36468	6871	3905	8165
	1816	663	482	900	6098	5180	7240	1684	226	3053	18700	14987	21813	3517	2751	4171
	1825	711	564	890	6181	4760	7320	2053	509	3279	18407	14677	21618	3512	2796	4171
	1851	744	614	842	10466	9460	11460	1148	226	2544	31340	26856	33511	6938	3994	8254
822-1B	1815	740	652	1044	9190	7680	10420	411	57	1018	28339	24184	30567	5752	5236	6346

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PH			TOTAL IONS, PPM			PERCENT GYPSUM SATURATION			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
815-1A	1815	5.60	4.94	6.33	12619	10820	14741	103	87	115	5.7	-14.8	14.8
	1816	5.83	5.62	6.04	9303	7925	10702	102	90	119	5.5	-0.5	13.2
	1825	5.63	5.00	5.90	9392	7939	11062	106	90	127	6.0	-4.4	14.8
	1851	4.61	3.85	5.74	13264	10595	15131	118	90	139	1.5	-10.5	13.4
816-1A	1815	5.50	5.25	6.17	14857	14013	15590	102	91	112	6.1	-9.2	14.6
	1816	5.74	5.50	5.87	10313	9436	10643	103	92	128	3.3	-3.4	10.7
	1825	5.60	5.27	5.79	10340	9136	10782	101	62	121	4.6	-1.2	14.8
	1851	4.52	4.18	5.08	15556	14578	16621	115	98	133	2.8	-2.6	7.7
817-1A	1815	5.56	5.29	5.79	15893	15018	16508	103	93	115	6.3	-1.7	14.6
	1816	5.91	5.77	6.04	9301	8480	10247	98	84	114	3.9	0.1	12.8
	1825	5.78	5.57	6.00	9376	8233	10335	103	93	151	1.5	-4.3	6.5
	1851	4.66	4.36	4.91	16982	16280	17659	131	103	145	3.4	-5.8	14.1
818-1A	1815	5.55	5.27	5.75	17273	15270	19170	106	91	120	9.1	5.2	14.4
	1816	5.90	5.82	6.04	10042	9219	10951	100	92	112	2.7	-2.3	8.2
	1825	5.76	5.60	5.98	10133	9423	10801	100	80	110	3.1	-1.8	8.2
	1851	4.70	4.28	5.70	18267	16206	19989	132	110	171	5.1	-2.9	10.6
819-1A	1815	5.45	5.07	5.98	19448	15744	22874	101	80	120	7.2	-9.0	15.0
	1816	5.86	5.56	6.12	12129	10023	15325	99	85	119	0.6	-9.4	10.7
	1825	5.68	5.32	6.02	12170	9950	15591	101	80	122	0.6	-14.9	11.6
	1851	4.49	4.12	4.83	20426	17132	23914	118	83	155	5.6	-7.9	14.9
819-1B	1815	5.45	5.16	5.79	19356	17454	21396	108	97	130	12.0	7.7	15.0
	1816	5.87	5.78	6.00	12532	11459	13631	109	100	122	7.1	0.3	14.9
	1825	5.71	5.45	5.99	12469	11419	13712	112	104	128	6.1	-3.6	14.3
	1851	4.40	3.78	4.71	20371	17960	22305	130	117	139	10.7	1.6	14.9
820-1A	1815	5.56	4.58	6.40	48468	39465	59431	121	101	169	0.3	-10.8	12.8
	1816	6.05	5.40	6.89	29152	21471	36326	97	27	147	-1.6	-15.1	12.2
	1825	6.79	6.79	6.79	22279	16845	30027	89	46	116	-5.4	-14.8	8.8
	1851	4.80	3.36	5.66	48880	43687	58388	132	108	165	-1.8	-14.7	9.6
820-1B	1815	5.18	4.91	5.41	47119	42301	50069	125	113	153	3.0	-2.3	9.6
	1816	5.89	5.66	6.10	28168	23437	32213	101	85	148	3.9	-3.9	13.9
	1851	5.00	4.69	5.91	47433	40267	51035	135	121	152	0.4	-8.7	8.6
820-1C	1815	4.76	4.68	4.94	47027	43439	49727	145	123	215	0.5	-10.0	7.5
	1816	5.87	5.66	6.03	27070	24320	29389	91	32	154	6.8	-2.2	13.2
	1825	5.69	5.57	5.90	27157	24360	29830	94	37	154	5.0	-1.2	9.6
	1851	4.58	4.48	4.70	47810	44861	51191	150	130	204	-2.7	-12.7	3.8
821-1A	1815	4.00	4.00	4.00	46785	46785	46785	112	112	112	3.7	3.7	3.7
	1825	9.10	9.10	9.10	17074	17074	17074	91	91	91	-6.0	-6.0	-6.0
	1851	5.46	5.46	5.46	47635	47635	47635	119	119	119	1.8	1.8	1.8
822-1A	1815	5.15	4.30	5.60	50480	47010	57322	118	100	143	4.7	-2.7	14.2
	1816	5.74	5.60	6.00	30833	25051	34651	100	75	152	1.7	-12.7	10.2
	1825	5.59	5.30	6.10	31039	24780	34807	104	86	138	2.7	-5.3	15.0
	1851	4.86	4.00	5.50	50986	47516	55566	123	108	149	3.6	-4.5	12.9
822-1B	1815	5.06	4.50	5.50	44777	38897	48549	122	111	177	5.1	-2.9	11.6

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

RUN NO.	ANALYTICAL POINT	CA++			MG++			SO3=			SO4=			CL-		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
822-1B	1816	782	532	1136	5985	4720	6720	3279	961	4184	17352	12516	19765	3324	2751	3816
	1825	859	586	1160	5870	4580	6720	3479	1300	4410	17026	12245	19823	3247	2574	3728
	1851	756	646	1112	9243	8360	10160	997	113	1809	28294	24166	32498	5825	5192	6346
823-1A	1805	653	580	770	5820	5270	6340	67	23	170	19889	17299	21952	2534	2174	2840
	1816	881	640	1150	5870	5170	6450	5446	1561	8481	16628	12712	20248	2566	2263	2840
	1825	893	652	1128	5830	5020	6280	5503	1402	8029	16653	12506	19389	2545	2263	2840
	1851	952	630	1234	5902	5050	6470	5933	1742	8594	16833	13176	20019	2597	2263	2929
824-1A	1805	504	450	588	6160	5100	7200	104	23	498	21002	18299	25100	2698	2308	3018
	1816	605	506	778	6125	5220	7540	5173	2431	9838	17495	14717	21323	2653	2263	2929
	1825	643	514	928	6116	5300	7420	5605	2940	10178	17127	13373	21773	2681	2352	2973
	1851	711	574	982	6237	5500	7460	5888	3506	10178	17421	13692	21934	2729	2352	3106
825-1A	1805	624	510	806	6648	5800	7640	220	23	837	23187	20929	25379	3628	2973	5414
	1816	655	538	792	6550	5230	7520	2618	905	4693	21049	17360	24282	3475	2973	4038
	1825	693	546	860	6404	5300	6990	2739	1131	4693	20909	18295	24267	3378	1420	3994
	1851	755	566	940	6613	5600	7760	3047	1538	5089	21215	17775	23904	3509	2751	3994
826-1A	1805	669	590	842	6514	5330	7780	267	23	1402	21265	17446	23630	3955	3106	4571
	1816	705	614	1040	6353	5270	8300	2917	565	4184	18978	16476	22226	3899	2973	4526
	1825	741	610	1046	6314	5530	7360	3030	509	4750	18993	15529	24059	3848	2973	4482
	1851	805	666	1152	6388	5000	7740	3380	735	5145	19047	16116	24729	3921	2929	4526
851-1A	1815	1447	1355	1570	1141	1040	1240	39	8	88	2502	2180	2852	3705	3461	3951
	1816	1152	1000	1360	704	632	790	76	22	112	1932	1450	2296	2383	2130	2531
	1825	1145	928	1278	740	667	788	222	64	336	1978	1672	2354	2355	2176	2529
	1851	1541	1300	1675	1167	1038	1378	194	8	336	2920	2469	3592	3802	3373	4128
852-1A	1815	1577	1405	1990	1203	1119	1323	22	0	56	2718	2369	3050	3961	3567	4564
	1816	867	747	1037	714	627	837	54	22	147	1374	1107	1593	2254	2038	2437
	1825	848	632	1075	747	599	851	277	56	520	1435	1092	1775	2264	2038	2437
	1851	1971	1650	2425	1306	1229	1395	980	723	1379	3102	2761	3492	4487	4343	4742
853-1A	1815	1569	1115	1790	1355	1119	1479	35	0	316	2683	2285	2899	4190	3767	4675
	1816	1243	1065	1440	865	667	1011	62	32	124	1933	1526	2421	2671	2481	3102
	1825	1206	1005	1415	904	739	1035	228	22	429	2132	1602	2701	2609	2399	2947
	1851	1744	1080	2095	1349	1079	1463	313	22	995	2997	2280	3418	4198	3722	4764
854-1A	1815	1664	1345	1950	1314	1071	1507	33	0	192	2598	2189	2917	4325	3456	4963
	1816	1086	766	1445	891	721	973	58	0	147	1557	1077	2305	2860	2082	3057
	1825	1042	800	1460	925	755	1015	229	45	474	1605	1152	2342	2835	2082	3057
	1851	1819	1420	2210	1337	955	1559	384	22	1007	3075	2681	3805	4456	3412	4919
855-1A	1815	1046	884	1285	304	236	372	24	0	56	1986	1720	2331	989	801	1418
	1816	853	795	922	78	44	121	35	11	64	1515	1356	1647	461	244	621
	1825	917	842	1026	176	71	419	217	27	475	1728	1509	1982	569	244	976
	1851	1202	1140	1280	290	249	375	314	226	386	2088	1875	2545	1088	826	1420
856-1A	1815	1277	964	1605	565	425	766	91	11	304	1952	1628	2608	2063	1373	3106
	1816	958	830	1160	224	127	369	57	11	102	1629	1461	1852	880	531	1487
	1825	964	832	1130	272	141	424	233	113	392	1763	1448	2106	837	531	1397
	1851	1455	1207	1638	565	446	760	448	57	937	2113	1692	2333	2111	1462	3106

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PH			TOTAL IONS, PPM			PERCENT GYPSUM SATURATION			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
822-1B	1816	5.53	5.40	6.30	30896	23535	35251	111	77	168	0.3	-11.6	8.9
	1825	5.40	5.20	6.10	30654	23474	35436	121	86	174	-0.1	-12.7	11.5
	1851	4.66	4.00	5.10	45463	41085	50798	124	102	193	3.9	-5.0	14.7
823-1A	1805	6.30	5.94	6.80	29162	25985	31357	106	90	122	5.8	-2.8	12.9
	1816	5.25	4.94	5.70	31582	26603	34095	121	94	166	-3.9	-11.2	6.4
	1825	5.15	4.84	5.70	31611	27553	34305	123	99	169	-4.8	-13.2	4.2
	1851	4.85	4.40	5.30	32408	28500	35690	131	96	174	-6.1	-14.7	2.5
824-1A	1805	5.91	5.80	6.10	30685	26830	35748	84	74	103	4.1	-5.6	11.2
	1816	5.24	4.90	5.50	32267	28542	37544	86	69	117	-5.3	-14.5	7.0
	1825	5.15	4.80	5.50	32386	28474	37818	90	58	127	-5.8	-14.4	10.1
	1851	4.80	4.50	5.10	33201	29025	38748	99	77	170	-5.8	-16.8	10.0
825-1A	1805	5.67	5.30	6.00	34531	31687	37590	107	86	134	-1.1	-10.3	8.5
	1816	5.45	5.10	6.00	34566	29809	37911	104	89	130	-4.1	-11.4	5.4
	1825	5.37	5.00	6.00	34350	31209	37432	111	91	139	-5.3	-14.9	2.6
	1851	5.11	4.70	7.00	35364	32039	38967	119	98	154	-4.9	-11.9	7.0
826-1A	1805	5.46	5.20	5.80	32919	28172	36819	107	92	136	2.7	-13.6	11.7
	1816	5.35	5.10	5.60	33097	28178	37121	105	84	157	-2.3	-17.5	14.0
	1825	5.29	5.00	5.50	33169	28345	37205	110	90	171	-2.7	-18.3	8.1
	1851	5.02	4.70	5.20	33790	28213	38984	119	93	188	-3.4	-13.8	6.2
851-1A	1815	4.43	4.11	4.63	9066	8851	9513	94	90	102	9.5	5.7	14.3
	1816	7.88	7.65	8.25	6367	5966	6861	81	59	107	8.4	1.5	10.7
	1825				6566	6117	7215	81	60	98	7.4	4.9	9.5
	1851	3.60	3.30	4.03	9853	9172	10867	111	98	128	4.3	0.5	6.4
852-1A	1815	5.63	5.04	6.11	9759	9209	10430	104	90	117	9.7	0.9	14.7
	1816	7.83	6.57	8.28	5404	4892	6023	49	43	58	12.2	7.9	18.0
	1825				5712	4763	6516	50	33	71	6.9	-9.3	14.3
	1851	4.28	3.87	4.56	12138	11073	12939	130	103	159	-0.1	-8.5	3.7
853-1A	1815	4.80	4.19	5.37	10117	9291	10727	97	82	105	12.3	5.1	18.8
	1816	8.03	7.57	8.29	6921	6203	8064	77	56	98	15.1	8.6	19.4
	1825	5.48	5.16	6.02	7224	6439	8416	81	58	101	11.2	5.5	17.2
	1851	4.92	3.37	5.65	10878	10064	11780	114	85	132	8.9	-10.2	15.6
854-1A	1815	5.05	4.62	5.50	10213	8687	11364	99	82	118	11.8	2.2	15.2
	1816	8.02	7.70	8.21	6597	5186	7814	58	35	96	13.3	9.5	16.5
	1825	5.64	5.31	6.12	6781	5482	8126	57	37	97	10.4	2.0	19.2
	1851	3.82	3.03	4.50	11364	9499	12579	121	104	165	5.3	-8.6	13.6
855-1A	1815	4.71	4.44	5.14	4420	3779	4990	106	91	123	12.3	-1.1	14.5
	1816	8.11	7.99	8.30	2980	2707	3321	100	97	107	9.5	0.0	15.6
	1825	5.61	5.31	6.21	3648	2915	4320	102	88	113	5.9	-4.8	13.9
	1851	3.60	3.32	4.36	5057	4726	5780	118	113	129	5.2	-9.2	12.4
856-1A	1815	5.10	4.37	5.50	6036	4888	7511	94	80	126	10.6	1.7	14.8
	1816	8.07	7.82	8.30	3798	3129	4780	94	89	113	11.4	6.1	18.0
	1825	5.41	5.25	5.68	4115	3316	5102	96	84	110	8.1	1.4	14.2
	1851	3.64	3.05	4.64	6781	5900	8094	108	87	121	6.1	-4.0	15.8

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

RUN NO.	ANALYTICAL POINT	CA++			MG++			SO3=			SO4=			CL-		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
857-1A	1815	1782	1582	2005	838	737	924	64	11	158	1987	1836	2272	3627	2969	4210
	1816	1210	1042	1345	446	365	519	88	22	147	1761	1627	1970	1840	1462	2348
	1825	1219	1042	1330	466	385	528	332	67	497	1823	1657	2022	1815	1396	2082
	1851	1953	1710	2195	863	735	947	505	67	927	2116	1420	2563	3701	3102	4210
858-1A	1815	2443	1895	3354	1063	805	1227	20	0	45	2057	1767	2567	5146	4165	6736
	1816	984	845	1117	300	257	350	47	22	85	1595	1151	1939	1243	1019	1373
	1825	988	850	1115	332	285	399	212	49	452	1710	1264	1954	1259	1063	1471
	1851	2611	2060	3400	1064	803	1214	427	316	576	2144	1764	2434	5270	4165	7312
859-1A	1815	2116	1910	2345	957	772	1112	99	67	192	1856	1695	2057	4537	4298	4875
	1816	1350	1217	1507	569	473	656	78	45	101	1222	880	1698	2785	2681	2925
	1825	1340	1170	1567	588	511	661	194	67	429	1380	903	2123	2745	2614	2880
	1851	2332	2110	2584	936	797	1019	837	610	1062	2127	1980	2369	4517	4165	4875
859-1B	1815	2007	1830	2160	1045	964	1122	33	0	56	2140	1982	2239	4390	4165	4609
	1816	1441	1335	1552	595	509	670	63	11	128	1772	1670	1932	2566	2348	2836
	1825	1466	1430	1547	614	582	664	304	248	361	1880	1722	2052	2516	2348	2614
	1851	2180	1855	2400	1016	909	1129	514	226	757	2339	2092	2496	4312	3722	4697
859-1C	1815	2317	1905	2825	944	867	1009	87	16	180	1912	1712	2096	4872	4099	5938
	1816	1437	1382	1500	602	529	679	51	22	90	1715	1562	1889	2731	2481	3102
	1825	1424	1350	1477	602	528	697	256	4	497	1771	1459	2219	2687	2508	2969
	1851	2497	2175	2925	948	849	1044	922	746	1108	1995	1760	2292	4991	4099	6160
859-1D	1815	2265	2125	2560	1013	824	1064	90	45	113	2126	1986	2351	4877	4742	5052
	1816	1229	1042	1445	594	550	668	54	33	79	946	606	1420	2954	2836	3146
	1825	1203	1030	1517	576	474	622	86	33	180	881	560	1751	2912	2809	3102
	1851	2324	2100	2480	1028	919	1084	762	678	859	2271	2004	2543	4930	4786	5074
860-1A	1815	2799	2310	3479	1145	1007	1249	22	0	45	1852	1721	2109	6515	5406	7888
	1816	1489	1230	1725	596	483	682	39	11	67	1317	1111	1565	3060	2437	3545
	1825	1507	1277	1637	620	529	702	49	11	79	1374	1162	1654	3063	2419	3678
	1851	2811	2210	3660	1134	974	1259	265	169	395	2097	1883	2473	6417	5052	7977
861-1A	1815	2689	2355	3270	1833	1564	2054	38	11	90	2227	1960	2379	8150	6958	8996
	1816	1791	1420	2000	1030	964	1107	91	22	124	1972	1445	2492	4512	4121	4830
	1825	1789	1570	1970	1082	967	1224	116	67	158	2131	1508	2690	4513	4033	4830
	1851	2825	2340	3695	1845	1579	2029	265	33	542	2504	1146	3042	8163	7418	9041
862-1A	1815	3244	2739	3960	1877	1354	2259	29	0	67	2255	1963	2660	9031	7489	10858
	1816	1484	1195	1755	687	499	954	85	22	135	1782	1468	2107	3191	2526	4033
	1825	1461	1185	1690	716	514	994	181	33	339	1890	1520	2356	3153	2481	4033
	1851	3456	2970	4399	1884	1449	2209	455	203	678	2632	2266	2955	9140	7622	11389
863-1A	1815	3003	2600	3850	2342	1849	2949	36	4	237	2579	2161	2925	10013	8863	12763
	1816	1962	1680	2380	1310	1157	1492	80	22	147	2398	1973	4088	5362	4254	6390
	1825	2002	1675	2450	1315	1149	1569	353	56	882	2638	1990	5043	5296	3825	6301
	1851	3207	2580	4339	2339	1459	2884	471	22	1368	2929	2052	5850	10072	9041	12187
864-1A	1815	3214	2920	3629	2442	2224	2630	26	8	36	2499	2305	2667	10920	10193	11538
	1816	2196	1990	2355	1420	1332	1484	84	22	167	2332	2075	2534	5937	5503	6257
	1825	2148	2010	2490	1405	1320	1474	208	56	441	2439	2137	2732	5929	5717	6204

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PH			TOTAL IONS, PPM			PERCENT GYPSUM SATURATION			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
857-1A	1815	5.38	4.71	6.21	8404	7546	9180	98	90	110	9.9	-1.4	14.2
	1816	8.03	7.83	8.28	5408	4843	5978	91	83	100	8.4	-8.5	13.6
	1825	5.54	5.11	6.70	5721	4950	6170	93	84	102	3.7	-15.2	11.9
	1851	4.27	3.45	6.62	9244	7692	10451	107	75	132	6.4	-4.8	13.7
858-1A	1815	5.51	5.33	5.75	10854	9350	13232	107	96	131	11.6	4.8	14.4
	1816	7.98	6.90	8.45	4232	3576	4846	86	60	103	8.5	-1.6	14.1
	1825	5.40	5.02	5.66	4566	3901	5135	89	62	102	3.2	-5.3	11.2
	1851	3.64	2.98	4.41	11642	9984	13838	115	101	136	8.0	-2.5	13.5
859-1A	1815	5.49	5.29	5.66	9695	9422	10152	95	88	102	10.3	0.9	14.9
	1816	8.10	8.00	8.29	6072	5602	6794	63	47	89	9.0	-0.6	13.9
	1825				6317	5452	7330	69	46	104	5.5	-15.0	13.1
	1851	4.58	4.37	4.77	10885	10594	11168	114	105	130	2.6	-8.6	12.2
859-1B	1815	5.49	5.12	5.65	9777	9380	10308	102	97	108	11.8	8.4	14.6
	1816	8.01	7.78	8.32	6535	6087	7074	90	86	98	10.8	7.5	12.5
	1825				6872	6493	7145	95	89	105	7.2	1.6	13.0
	1851	4.02	3.17	4.64	10523	9442	10969	117	102	126	7.3	3.7	14.3
859-1C	1815	5.60	5.23	6.41	10275	9265	11703	102	96	112	9.7	5.7	14.6
	1816	8.01	7.70	8.19	6619	6427	6992	87	80	95	8.1	2.0	14.8
	1825				6826	6544	7168	89	72	112	3.6	-6.0	9.8
	1851	4.56	4.44	4.68	11505	10531	12986	110	104	118	1.3	-7.8	9.4
859-1D	1815	5.36	4.89	5.58	10520	10230	10998	110	98	126	8.8	7.4	11.4
	1816	7.93	7.42	8.12	5863	5234	6805	47	28	71	8.0	0.3	10.4
	1825				5744	5287	7184	43	30	90	7.1	-0.6	12.9
	1851	4.60	4.41	4.75	11462	11090	11972	117	103	136	0.1	-5.9	4.6
860-1A	1815	5.52	5.36	5.75	12496	10740	14508	101	93	109	7.0	-2.9	11.4
	1816	8.04	7.90	8.21	6593	5572	7320	69	57	86	9.5	5.8	14.6
	1825				6706	5779	7703	72	59	91	10.4	4.0	14.3
	1851	3.78	3.40	4.35	12884	10818	15440	114	105	128	3.3	-5.7	5.9
861-1A	1815	5.49	5.20	5.98	15187	13352	16712	97	93	108	5.6	-1.8	12.8
	1816	7.83	6.79	8.20	9532	8282	10454	90	60	120	4.8	-4.3	11.2
	1825	5.86	5.12	6.37	9768	8533	10711	94	69	122	4.9	-2.8	11.4
	1851	3.26	2.89	4.29	15838	14698	17785	111	57	143	3.8	-6.0	13.1
862-1A	1815	5.54	5.17	5.71	16746	14320	19473	109	94	131	7.7	2.5	12.2
	1816	8.01	7.66	6.36	7350	6066	8910	87	74	98	4.0	-3.8	9.4
	1825	5.78	5.17	7.46	7522	6199	9540	90	75	106	2.4	-2.3	11.0
	1851	4.30	4.00	4.52	17888	15632	21198	131	107	144	4.5	1.4	11.2
863-1A	1815	5.60	4.90	7.04	18556	16467	21622	107	89	130	7.0	-11.9	14.8
	1816	7.81	5.95	8.16	11425	10232	14200	102	80	175	6.2	-13.7	13.9
	1825	4.89	3.79	5.31	11919	10361	14380	112	84	214	2.7	-8.4	19.4
	1851	4.24	3.40	4.89	19610	17787	22704	126	91	240	4.1	-9.4	14.8
864-1A	1815	5.59	5.41	5.78	19713	18544	20658	106	95	116	5.7	2.0	14.0
	1816	7.84	7.53	8.16	12286	11495	12722	102	90	112	8.1	4.7	13.9
	1825				12428	11905	13006	106	96	123	4.3	1.4	9.4

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

RUN NO.	ANALYTICAL POINT	CA++			MG++			SO3=			SO4=			CL-		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
864-1A	1851	3328	2879	3649	2439	2239	2640	340	56	576	2793	2592	3091	11059	10370	11715
865-1A	1815	2667	2340	3199	1609	1444	1854	66	11	169	2195	2109	2281	8029	7268	9041
	1816	1807	1620	2070	993	902	1107	91	33	203	2116	2022	2291	4451	3722	4875
	1825	1840	1575	2110	997	902	1102	359	22	735	2314	1867	2598	4449	3767	4875
	1851	2869	2230	3489	1599	1469	1834	544	11	1029	2509	2234	2800	8087	7090	9138
866-1A	1815	2330	2010	2980	1701	1549	1884	51	11	214	2364	2103	2650	8077	7179	9484
	1816	1647	1445	2050	882	742	969	83	33	147	2004	1732	2293	4259	4077	4609
	1825	1576	1400	1775	876	732	977	164	33	508	2046	1731	2476	4256	4077	4520
	1851	2478	2070	3039	1674	1484	1904	467	40	1402	2730	2204	3387	8058	7090	9306
867-1A	1815	1768	1540	2245	1800	1539	2174	41	0	90	2706	2459	3190	6692	6027	7241
	1816	1240	1080	1455	905	814	992	78	45	124	2218	2074	2413	3367	3013	3634
	1825	1238	1085	1410	909	772	999	274	67	689	2320	1978	2505	3357	3013	3678
	1851	1854	1620	2050	1793	1579	2019	373	33	768	3094	2710	3388	6797	6204	7090

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PH			TOTAL IONS, PPM			PERCENT GYPSUM SATURATION			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
864-1A	1851	4.38	3.92	5.91	20580	19553	21457	121	108	137	2.5	-1.9	9.0
865-1A	1815	5.58	5.41	5.90	15090	13989	16310	102	95	116	3.2	-8.9	13.0
	1816	7.82	7.45	8.14	9733	8799	10419	98	91	108	5.2	-4.2	12.6
	1825				10225	9193	11088	107	91	118	0.1	-8.1	9.5
	1851	4.53	4.08	5.66	16147	14619	17611	120	103	137	-0.6	-11.8	11.0
866-1A	1815	5.56	4.95	7.75	15003	13917	16672	98	90	109	-2.4	-12.4	9.5
	1816	7.84	7.40	9.02	9185	8461	10087	92	85	102	0.9	-5.1	10.5
	1825				9214	8381	10118	92	85	105	-3.6	-12.5	3.9
	1851	4.56	4.00	4.90	15910	14791	16991	117	100	142	-6.9	-13.5	5.2
867-1A	1815	5.55	5.40	5.90	13473	12390	14814	91	84	102	2.2	-2.1	10.8
	1816	7.82	6.77	9.12	8048	7409	8590	86	81	100	0.9	-5.1	5.8
	1825				8342	7561	9163	89	78	98	-3.5	-13.0	4.5
	1851	4.38	4.04	4.68	14384	13427	15098	106	97	114	-3.8	-9.1	1.6

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

RUN NO.	ANALYTICAL POINT	CO2			SO2			SO3			CAO			ACID INSOLUBLES, WT % IN SLURRY			SOLIDS, WT % IN SLURRY		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
VFG-1A	1816	0.49	0.19	0.77	25.72	12.84	29.68	2.97	0.02	5.93	26.40	13.03	30.50	2.52	2.23	2.85	8.6	7.6	13.3
VFG-1B	1816	2.43	1.49	4.12	36.67	33.48	38.65	2.90	0.16	7.61	39.27	35.69	42.62	0.16	0.04	0.28	8.4	7.8	9.1
VFG-1C	1816	1.50	0.54	2.47	22.36	18.82	32.55	2.47	0.55	4.01	24.40	20.36	34.83	2.97	2.58	3.36	8.7	8.1	9.8
	1825																		
VFG-1D	1816	2.85	1.37	4.95	22.62	17.73	25.69	1.81	0.03	7.38	26.22	21.75	30.13	2.40	2.24	2.55	8.0	7.3	8.5
	1825																		
VFG-1E	1816	2.20	0.88	4.73	23.01	18.82	26.42	3.52	0.33	9.23	26.03	21.35	29.37	2.86	2.50	3.24	8.4	8.0	8.9
	1825																		
VFG-1F	1816	1.16	0.33	2.25	16.30	12.66	23.91	2.18	0.12	6.52	18.18	15.21	27.51	4.42	3.72	5.97	8.9	7.3	15.0
	1825																		
VFG-1G	1816	3.11	2.03	3.90	21.26	14.04	25.69	1.83	0.26	3.89	24.57	18.13	28.24	3.48	3.20	3.77	8.3	7.2	8.9
	1825																		
VFG-1I	1816	2.10	1.52	2.80	22.97	19.72	26.79	4.42	1.00	8.07	27.24	25.61	28.66	4.77	3.83	5.72	14.6	8.3	15.9
	1825																		
VFG-1P	1816	1.76	1.33	2.58	20.73	18.09	25.44	2.61	0.06	8.05	23.27	19.76	26.97	2.93	2.40	3.30	8.6	7.5	13.4
	1825																		
VFG-1Q	1816	3.75	2.82	4.31	40.35	38.36	43.43	4.88	0.47	10.11	41.69	40.22	43.37	0.22	0.15	0.28	15.0	14.4	15.6
601-1A	1815	2.40	1.64	3.96	19.54	15.12	23.06	5.56	1.30	14.01	23.75	19.38	27.70				8.1	7.0	9.4
	1825																		
601-1B	1815	2.52	1.25	9.46	19.04	12.56	22.29	5.87	2.86	10.24	23.03	19.31	33.93				7.9	2.0	9.0
	1825																		
601-1C	1815	2.85	2.14	3.96	18.44	15.95	23.06	6.28	3.26	9.37	24.04	23.02	25.25				7.9	7.0	8.8
	1825																		
602-1A	1815	2.61	1.98	3.63	21.10	16.85	25.37	5.81	0.84	11.49	25.31	22.76	27.14				8.7	7.7	10.0
	1816	3.16	3.16	3.16	22.29	22.29	22.29	5.49	5.49	5.49	26.99	26.99	26.99				8.6	8.6	8.6
	1825																		
603-1A	1815	2.36	1.28	3.41	20.73	17.36	23.51	5.36	1.26	8.77	24.07	22.30	26.08				15.2	13.3	16.9
	1816	2.45	2.45	2.45	22.17	22.17	22.17	3.36	3.36	3.36	23.90	23.90	23.90				15.0	15.0	15.0
	1825																		
604-1A	1816	2.78	1.04	8.92	20.33	15.30	24.00	5.28	0.72	10.99	26.38	19.90	29.60	3.83	2.90	7.04	8.4	6.8	15.2
	1825																		
605-1A	1816	2.59	1.73	3.90	19.95	16.70	22.90	5.53	3.46	11.23	26.35	25.10	28.40	3.80	3.17	4.34	8.5	7.5	9.3
	1825																		
606-1A	1816	2.79	1.80	8.14	20.81	19.30	22.20	5.37	3.80	6.98	27.04	25.70	31.70	3.63	3.18	4.09	8.3	7.5	9.0
607-1A	1816	2.07	1.63	2.50	21.40	19.20	24.10	6.24	3.95	8.50	27.36	26.80	28.60	3.60	3.27	4.25	8.4	7.9	9.4
	1825																		
608-1A	1816	2.05	1.30	3.11	20.42	16.10	22.70	6.44	3.88	10.59	25.15	22.88	28.30	3.67	3.00	4.50	8.2	6.5	9.4
609-1A	1816	2.28	1.34	3.00	20.73	14.10	23.90	6.75	3.55	15.71	24.94	23.90	26.38	3.66	2.75	4.11	8.5	7.9	9.1
610-1A	1816	2.74	2.01	4.01	20.46	17.20	23.50	6.13	2.76	8.10	24.91	23.31	26.71	3.90	3.09	5.40	9.0	7.4	12.1
611-1A	1816	1.33	0.68	1.92	23.82	19.73	26.30	6.95	1.92	9.94	26.19	23.34	27.79	3.54	3.00	4.07	7.8	7.3	8.4
612-1A	1816	0.67	0.60	0.74	19.45	17.20	21.70	7.77	6.46	9.07	22.47	22.01	22.93	4.03	3.20	4.85	7.8	6.2	9.3
618-1A	1815	1.89	1.60	2.28	18.48	17.10	20.56	6.12	3.23	9.39	24.16	22.62	25.94				8.4	7.3	9.7
	1816	1.73	1.48	2.17	18.09	14.90	20.60	8.70	5.94	11.80	22.71	20.62	25.51	4.12	3.66	4.56	8.3	7.3	9.7

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PERCENT SULFITE OXIDATION AVG	PERCENT SULFITE OXIDATION MIN	PERCENT SULFITE OXIDATION MAX	STOICHIOMETRIC RATIO AVG	STOICHIOMETRIC RATIO MIN	STOICHIOMETRIC RATIO MAX	PERCENT IONIC IMBALANCE AVG	PERCENT IONIC IMBALANCE MIN	PERCENT IONIC IMBALANCE MAX
VFG-1A	1816	8.3	0.1	17.4	1.03	1.01	1.09	4.5	-3.5	7.9
VFG-1B	1816	5.8	0.4	14.5	1.09	1.05	1.16	5.0	-2.6	8.4
VFG-1C	1816	7.9	2.3	12.1	1.09	1.03	1.19	4.9	-2.6	7.7
	1825									
VFG-1D	1816	5.9	0.1	25.0	1.17	1.09	1.28	5.8	1.1	8.4
	1825									
VFG-1E	1816	10.3	1.3	24.3	1.12	1.05	1.30	2.5	-6.1	7.6
	1825									
VFG-1F	1816	9.3	0.6	20.5	1.10	1.02	1.20	4.9	-0.4	8.3
	1825									
VFG-1G	1816	6.3	0.8	13.1	1.21	1.12	1.35	3.0	-2.6	7.4
	1825									
VFG-1I	1816	13.4	2.9	24.5	1.12	1.08	1.16	5.0	1.4	8.2
	1825									
VFG-1P	1816	9.1	0.2	21.0	1.11	1.07	1.17	4.4	-3.3	8.1
	1825									
VFG-1Q	1816	8.7	0.9	17.4	1.12	1.09	1.14	-4.4	-6.5	-1.1
601-1A	1815	18.4	4.4	38.0	1.15	1.10	1.25	-1.4	-8.5	7.0
	1825									
601-1B	1815	20.0	10.6	38.3	1.15	1.08	1.52	-4.2	-8.5	8.2
	1825									
601-1C	1815	21.4	10.2	31.1	1.18	1.13	1.25	-0.5	-6.7	5.2
	1825									
602-1A	1815	18.0	2.6	34.5	1.15	1.11	1.23	-2.3	-8.1	8.5
	1816	16.5	16.5	16.5	1.17	1.17	1.17	-1.5	-1.5	-1.5
	1825									
603-1A	1815	17.2	4.2	28.8	1.14	1.07	1.21	-3.6	-7.5	7.3
	1816	10.8	10.8	10.8	1.14	1.14	1.14	-4.1	-4.1	-4.1
	1825									
604-1A	1816	17.1	2.6	32.2	1.17	1.06	1.59	5.1	-6.8	8.5
	1825									
605-1A	1816	18.2	11.0	35.0	1.16	1.10	1.22	6.5	2.6	8.4
	1825									
606-1A	1816	17.2	12.2	22.1	1.17	1.10	1.50	5.6	1.9	7.0
607-1A	1816	16.9	12.5	26.2	1.11	1.09	1.14	5.9	3.0	7.8
	1825									
608-1A	1816	20.2	12.1	33.8	1.12	1.08	1.18	0.4	-8.4	8.1
609-1A	1816	20.6	11.0	47.1	1.13	1.07	1.18	-3.4	-7.5	2.8
610-1A	1816	19.3	9.4	27.4	1.16	1.11	1.25	-3.2	-8.5	1.7
611-1A	1816	18.9	5.5	27.7	1.07	1.04	1.10	-4.7	-8.4	-0.8
612-1A	1816	24.5	19.2	29.7	1.04	1.03	1.04	-3.8	-5.9	-1.6
618-1A	1815	20.8	11.7	30.5	1.12	1.10	1.14	5.3	-0.2	7.1
	1816	27.8	19.3	36.0	1.10	1.08	1.12	-6.3	-8.5	-2.3

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

RUN NO.	ANALYTICAL POINT	CO2			SO2			SO3			CAO			ACID INSOLUBLES, WT % IN SLURRY			SOLIDS, WT % IN SLURRY		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
618-1A	1825																		
619-1A	1816	2.15	0.97	4.83	18.89	13.50	22.80	9.46	7.02	13.33	24.55	21.61	28.10	3.63	3.00	4.33	7.9	6.6	9.4
	1825																		
620-1A	1815																		
	1816	1.86	1.35	2.56	18.89	16.90	21.30	5.96	4.14	9.17	23.17	21.64	24.14	4.10	3.00	4.73	8.3	6.9	9.5
	1825																		
621-1A	1816	2.16	1.79	2.51	17.22	16.00	18.30	6.48	4.71	7.57	22.64	21.94	23.43	4.23	3.90	4.84	8.3	7.9	9.4
622-1A	1816	1.91	0.88	3.76	19.78	14.20	23.80	6.33	2.00	9.79	23.63	21.48	27.20	3.87	3.12	4.55	8.2	6.4	9.6
	1825																		
623-1A	1816	2.36	1.83	2.87	22.41	20.80	24.40	4.71	2.68	6.77	24.58	23.52	25.24	3.59	3.08	4.07	8.0	7.2	8.9
	1825																		
624-1A	1816	1.82	0.73	3.06	19.97	14.80	25.90	6.70	2.09	10.32	23.73	19.16	26.93	3.96	3.05	6.09	8.6	6.9	13.8
	1825																		
625-1A	1816	1.91	1.25	2.39	19.19	15.40	23.50	7.68	3.82	11.82	25.00	19.87	29.28	3.52	2.12	4.61	8.1	4.5	9.4
	1825																		
626-1A	1816	1.70	1.15	2.51	18.60	14.20	24.10	7.16	4.36	11.78	23.73	21.10	29.45	3.92	2.72	5.06	8.5	7.5	9.6
	1825																		
627-1A	1816	2.33	1.20	3.72	20.22	16.70	23.42	4.99	3.63	8.03	24.28	22.90	25.00	7.36	7.35	7.36	15.1	14.6	15.9
	1825																		
628-1A	1816	1.85	0.48	6.55	19.23	13.00	22.80	7.16	3.74	10.78	23.40	21.10	26.62	4.46	3.07	6.34	9.6	6.7	12.5
	1825																		
628-1B	1816	1.92	1.09	3.00	20.22	15.60	24.70	6.82	4.33	9.47	24.31	21.58	26.70	4.05	3.12	4.61	9.0	7.6	10.2
	1825																		
629-1A	1816	0.45	0.11	1.26	23.43	18.00	27.30	8.05	3.40	14.10	26.10	23.00	30.00	3.66	2.56	5.12	8.9	6.9	13.3
630-1A	1816	0.73	0.43	1.10	24.33	19.40	31.10	5.59	3.18	9.16	25.75	22.50	29.30	3.79	3.00	4.47	8.6	7.4	9.7
631-1A	1816	0.63	0.27	1.21	21.34	15.90	26.90	6.27	2.08	9.93	24.04	20.00	29.50	3.97	2.56	5.23	8.4	5.6	9.7
632-1A	1816	0.58	0.37	0.86	22.23	19.60	29.10	5.42	3.23	9.95	23.75	21.70	27.20	3.97	2.80	4.90	8.2	7.5	9.3
633-1A	1816	1.01	0.58	1.33	25.34	21.00	28.90	5.14	3.08	8.01	26.66	23.40	29.30	3.55	2.83	4.80	8.3	7.1	10.2
634-1A	1816	3.83	2.51	6.43	35.56	28.90	40.40	4.17	0.51	11.16	38.16	34.20	43.40	0.93	0.42	1.47	4.3	3.4	6.1
635-1A	1816	3.00	1.70	5.17	35.79	28.20	40.10	10.48	2.21	19.26	42.44	39.50	45.30	0.87	0.02	1.78	8.3	7.2	9.3
636-1A	1816	3.08	1.76	3.68	35.84	32.60	39.45	9.74	3.55	18.78	43.24	39.50	46.96	0.58	0.01	1.29	8.3	7.7	9.1
637-1A	1816	1.67	1.18	2.30	37.90	36.30	39.09	9.21	2.54	15.43	42.66	40.81	44.04	0.15	0.07	0.35	8.3	7.7	9.2
638-1A	1816	1.81	0.44	2.47	35.81	33.29	37.64	9.42	1.49	16.67	39.97	36.33	44.23	0.03	0.01	0.10	4.6	3.6	8.1
639-1A	1816	1.30	0.28	2.10	35.87	26.62	42.29	14.82	5.25	25.92	41.54	33.23	46.88	0.06	0.01	0.30	3.9	0.0	5.5
640-1A	1816	1.33	0.94	1.80	37.22	32.75	38.91	14.93	7.46	23.43	43.54	40.25	46.03	0.33	0.02	1.34	8.3	7.7	9.4
641-1A	1816	1.26	0.62	1.74	40.87	35.65	43.11	7.68	1.42	15.27	42.13	39.55	45.37	0.09	0.03	0.16	8.1	7.5	8.5
642-1A	1816	0.81	0.32	1.28	38.71	35.47	41.98	8.24	0.48	13.78	40.15	38.14	43.53	0.20	0.03	0.85	8.1	6.3	9.0
	1825																		
643-1A	1816	1.15	0.67	1.91	40.64	38.18	42.34	10.70	2.81	13.61	43.79	39.80	45.81	0.14	0.05	0.44	8.1	7.2	8.8
701-1A	1816	7.59	5.21	10.25	20.47	17.30	23.10	4.90	1.67	6.53	30.58	28.06	32.90	5.71	4.80	6.23	16.2	14.4	18.6
	1825																		
702-1A	1816	8.98	6.99	10.51	23.27	20.00	26.00	1.60	0.77	2.35	32.67	29.76	35.14	5.20	4.67	5.44	15.2	14.8	15.9
	1825																		

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PERCENT SULFITE OXIDATION AVG	MIN	MAX	STOICHIOMETRIC RATIO AVG	MIN	MAX	PERCENT IONIC IMBALANCE AVG	MIN	MAX
618-1A	1825									
619-1A	1816	28.9	19.8	44.1	1.12	1.06	1.26	-5.5	-8.2	-2.7
	1825									
620-1A	1815									
	1816	20.1	13.6	29.1	1.12	1.08	1.17	0.4	-4.8	3.7
	1825									
621-1A	1816	23.2	17.2	27.5	1.14	1.11	1.17	1.2	-2.2	3.9
622-1A	1816	20.5	6.5	35.6	1.11	1.05	1.20	-2.3	-8.5	6.6
	1825									
623-1A	1816	14.4	8.1	19.8	1.13	1.10	1.16	-5.5	-8.1	-1.9
	1825									
624-1A	1816	21.3	6.5	30.6	1.10	1.04	1.18	-3.2	-8.5	4.7
	1825									
625-1A	1816	24.4	11.9	36.6	1.11	1.07	1.13	1.1	-7.7	7.9
	1825									
626-1A	1816	23.8	13.1	39.8	1.10	1.07	1.18	1.1	-8.3	7.5
	1825									
627-1A	1816	16.6	11.2	27.8	1.14	1.08	1.25	0.5	-7.7	7.9
	1825									
628-1A	1816	23.1	12.7	39.8	1.11	1.03	1.44	-3.5	-8.0	4.9
	1825									
628-1B	1816	21.4	12.3	28.8	1.11	1.06	1.17	-2.6	-7.5	8.3
	1825									
629-1A	1816	21.4	10.3	31.3	1.02	1.00	1.07	-2.3	-7.8	6.3
630-1A	1816	15.6	9.0	21.9	1.04	1.02	1.07	-1.4	-8.4	3.9
631-1A	1816	19.0	7.5	33.3	1.04	1.01	1.08	0.7	-4.1	7.3
632-1A	1816	16.2	8.2	27.2	1.03	1.02	1.05	-0.9	-6.4	4.4
633-1A	1816	13.9	7.9	19.6	1.05	1.03	1.06	-1.5	-6.3	4.2
634-1A	1816	8.5	1.0	20.7	1.15	1.09	1.26	-2.2	-8.3	7.6
635-1A	1816	18.5	4.5	35.3	1.10	1.05	1.21	-0.1	-7.5	7.6
636-1A	1816	17.6	6.7	31.2	1.10	1.06	1.12	2.6	-6.3	7.7
637-1A	1816	16.0	5.1	24.4	1.05	1.04	1.08	2.1	-6.0	8.0
638-1A	1816	16.9	3.1	26.7	1.06	1.02	1.09	-0.7	-8.3	7.9
639-1A	1816	24.6	9.8	43.8	1.04	1.01	1.06	-4.6	-8.2	1.7
640-1A	1816	24.1	13.4	36.4	1.04	1.03	1.05	-2.8	-8.3	2.9
641-1A	1816	13.0	2.6	25.5	1.04	1.02	1.05	-1.5	-4.3	3.2
642-1A	1816	14.3	1.0	23.7	1.03	1.01	1.04	-1.4	-5.7	5.4
	1825									
643-1A	1816	17.3	5.1	21.3	1.03	1.02	1.06	-1.7	-6.1	2.0
701-1A	1816	16.1	5.5	22.2	1.46	1.30	1.67	-1.5	-7.7	6.4
	1825									
702-1A	1816	5.4	2.3	8.6	1.54	1.38	1.70	-1.1	-8.2	7.4
	1825									

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

RUN NO.	ANALYTICAL POINT	CO2			SO2			SO3			CAO			ACID INSOLUBLES, WT % IN SLURRY			SOLIDS, WT % IN SLURRY		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
703-1A	1816	0.88	0.05	1.97	19.82	14.30	23.10	5.18	2.84	9.30	21.00	16.05	22.31	8.07	7.10	10.30	15.2	14.4	17.3
704-1A	1816	7.85	2.18	11.15	18.13	14.00	22.00	4.62	1.66	11.09	29.63	22.54	33.89	5.94	4.17	7.73	15.3	13.8	16.3
705-1A	1816	4.02	2.97	6.15	24.56	20.30	27.90	2.78	0.59	5.79	28.60	22.82	30.92	5.72	4.70	6.52	14.8	13.9	15.6
706-1A	1816	2.62	0.38	5.27	20.04	19.50	20.50	5.57	3.70	7.05	23.75	19.78	27.05	7.11	5.56	9.43	15.0	14.1	16.4
707-1A	1816	5.77	3.30	8.31	22.60	18.00	24.30	3.19	0.73	6.39	27.49	23.81	29.40	6.09	5.35	7.56	15.1	14.3	16.0
708-1A	1816	4.03	0.84	6.64	21.87	20.30	23.90	5.27	2.74	7.35	26.37	22.20	28.30	6.13	5.11	7.98	14.7	14.2	15.4
709-1A	1816	5.72	3.60	9.57	22.53	19.70	26.10	3.71	2.00	5.99	28.16	25.66	30.30	6.03	4.56	6.99	15.0	13.4	16.6
710-1A	1816	7.66	1.02	10.80	20.93	17.30	25.40	3.12	0.06	7.25	29.82	22.90	34.40	5.69	2.97	7.53	15.0	7.9	17.4
711-1A	1816	4.85	2.36	7.31	20.90	16.40	25.30	3.40	1.03	6.59	25.92	23.98	28.30	6.64	5.75	7.50	14.7	13.0	16.2
711-1B	1816	5.93	2.75	7.98	18.18	15.00	23.90	3.83	1.90	5.22	26.16	23.17	28.75	6.93	6.40	7.76	15.0	13.7	15.8
712-1A	1816	9.11	4.93	11.54	19.78	16.70	24.20	3.38	1.78	5.25	30.27	27.96	32.84	5.69	5.04	6.25	15.3	14.6	16.3
712-1B	1816	8.66	1.23	19.25	19.31	13.30	22.30	2.11	0.03	3.98	28.32	21.80	36.00	5.85	4.99	6.71	15.3	13.9	16.7
713-1A	1816	2.02	1.25	4.46	19.15	16.50	22.20	4.96	2.52	7.27	22.84	21.64	24.74	7.18	6.45	7.73	14.1	12.9	15.3
714-1A	1816	5.04	3.23	7.55	21.21	18.80	23.70	4.61	1.65	6.66	27.24	24.68	31.75	6.11	4.85	7.26	15.0	13.5	16.3
715-1A	1816	5.67	5.28	6.05	18.18	15.10	21.30	3.43	1.58	4.44	26.17	24.46	28.04	7.69	5.94	8.29	16.4	14.9	18.7
716-1A	1816																		
717-1A	1816	4.60	1.98	16.76	20.79	2.30	25.30	5.83	1.25	13.03	27.94	22.91	33.64	6.24	4.03	8.54	15.4	13.7	17.5
718-1A	1816	6.34	1.47	10.43	29.45	22.70	32.70	12.18	6.56	20.78	43.40	38.70	49.80	0.77	0.06	3.11	7.7	3.9	8.8
801-1A	1815	0.68	0.02	2.80	1.74	0.18	16.28	14.61	2.17	40.09	13.12	4.20	36.68	7.95	5.62	10.00	14.9	10.3	22.6
	1816	5.00	1.87	9.13	32.69	7.60	39.45	7.24	0.97	46.43	41.77	36.47	44.01	0.22	0.16	0.31	5.9	3.7	10.0
	1825																		
	1851																		
802-1A	1815	1.72	0.16	6.32	0.55	0.00	1.75	15.54	5.02	29.48	13.82	6.85	24.23	5.70	0.54	10.08	14.6	10.9	16.8
	1816	9.03	2.69	15.28	28.14	19.54	35.47	7.41	2.14	12.97	42.17	36.86	45.41	0.25	0.11	0.57	5.9	4.6	8.0
	1825																		
	1851																		
803-1A	1815	1.54	0.44	4.07	0.56	0.18	1.09	16.02	9.46	22.40	13.64	8.09	18.80	7.28	4.31	10.46	14.9	11.3	17.8
	1816	8.87	1.49	13.39	27.13	19.90	32.57	7.33	3.05	17.19	41.87	37.72	44.44	0.23	0.15	0.27	5.1	2.4	7.1
	825																		
	1851																		
804-1A	1815	1.17	0.10	1.92	0.42	0.00	0.98	16.24	5.52	29.57	13.64	5.90	23.38	7.78	6.15	11.11	14.9	12.0	17.0
	1816	9.91	5.61	16.50	28.26	22.26	31.85	8.32	1.38	11.44	42.94	40.28	46.32	0.46	0.24	0.89	7.4	5.9	10.0
	1825																		
	1851																		
805-1A	1815	1.33	0.33	3.11	0.30	0.01	1.44	18.55	12.76	24.05	15.51	10.18	19.06	6.45	5.46	8.44	14.4	10.9	16.7
	1816	11.11	6.12	15.89	28.36	23.16	35.77	4.68	1.46	13.75	43.59	40.96	46.17	0.61	0.22	1.23	14.5	7.4	17.6
	1825																		
	1851																		
806-1A	1815	0.64	0.22	0.90	0.21	0.01	0.53	21.00	14.97	33.23	15.54	10.95	24.08	7.03	5.24	8.82	14.6	13.2	15.8
	1816	6.80	4.78	9.90	33.54	28.95	36.91	4.27	0.15	8.97	42.30	41.22	43.63	0.48	0.33	0.62	15.2	14.1	16.0
	1825																		
	1851																		
806-1B	1815	0.43	0.22	0.66	0.28	0.15	0.36	17.87	8.78	30.59	13.12	6.98	21.34	7.15	5.95	8.35	15.0	13.0	16.4

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PERCENT SULFITE OXIDATION			STOICHIOMETRIC RATIO			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
703-1A	1816	17.5	9.2	34.2	1.05	1.00	1.13	-5.3	-8.5	1.7
704-1A	1816	17.0	5.7	38.8	1.53	1.13	1.86	1.6	-4.1	7.8
705-1A	1816	8.2	1.8	16.2	1.22	1.15	1.36	-0.1	-7.6	6.8
706-1A	1816	18.1	13.2	21.7	1.15	1.02	1.31	-4.5	-7.8	0.6
707-1A	1816	10.2	2.5	22.1	1.34	1.20	1.52	-6.9	-8.4	-3.4
708-1A	1816	16.2	8.4	22.1	1.22	1.05	1.38	-6.1	-7.8	-4.7
709-1A	1816	11.6	6.4	18.2	1.33	1.19	1.62	-5.2	-8.5	3.3
710-1A	1816	10.7	0.2	24.1	1.48	1.06	1.73	-1.5	-6.9	7.4
711-1A	1816	11.7	3.5	24.1	1.30	1.15	1.49	-3.6	-8.3	2.8
711-1B	1816	14.8	6.0	21.5	1.42	1.16	1.62	-0.1	-7.1	7.8
712-1A	1816	12.1	6.5	18.1	1.59	1.28	1.77	-3.4	-7.4	3.7
712-1B	1816	8.4	0.1	19.3	1.65	1.08	2.70	-3.3	-8.2	8.0
713-1A	1816	17.2	9.4	25.6	1.13	1.07	1.32	0.1	-5.6	5.7
714-1A	1816	14.9	5.5	21.4	1.30	1.18	1.49	-3.7	-8.1	8.3
715-1A	1816	13.1	6.5	18.7	1.40	1.35	1.42	2.4	-7.6	8.1
716-1A	1816									
717-1A	1816	20.6	3.9	80.0	1.33	1.11	3.19	-0.8	-6.5	7.5
718-1A	1816	24.7	14.3	42.1	1.24	1.05	1.41	2.2	-7.9	8.0
801-1A	1815	87.6	22.1	98.8	1.10	1.00	1.66	3.2	-7.6	8.4
	1816	14.6	2.0	83.0	1.19	1.06	1.40	4.1	-3.6	8.5
	1825									
	1851									
802-1A	1815	94.9	78.8	100.0	1.23	1.01	1.85	1.9	-7.9	7.9
	1816	17.4	6.1	32.7	1.40	1.10	1.84	2.0	-4.1	8.2
	1825									
	1851									
803-1A	1815	95.8	91.7	98.2	1.17	1.05	1.50	-0.2	-7.3	7.3
	1816	17.6	7.4	34.8	1.41	1.05	1.72	4.0	-4.0	7.6
	1825									
	1851									
804-1A	1815	96.5	86.0	100.0	1.14	1.01	1.31	2.9	-6.7	7.8
	1816	15.1	4.1	24.5	1.44	1.22	1.88	2.7	-2.9	7.1
	1825									
	1851									
805-1A	1815	97.9	90.1	99.9	1.14	1.03	1.37	3.5	-2.3	7.6
	1816	11.6	4.3	32.2	1.52	1.23	1.95	3.0	-6.7	7.9
	1825									
	1851									
806-1A	1815	98.6	96.8	100.0	1.06	1.02	1.07	-1.0	-4.3	3.0
	1816	9.3	0.3	19.9	1.27	1.19	1.40	3.1	-2.7	7.6
	1825									
	1851									
806-1B	1815	97.6	95.8	99.3	1.06	1.01	1.13	-1.5	-5.6	3.2

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

RUN NO.	ANALYTICAL POINT	CO2			SO2			SO3			CAO			ACID INSOLUBLES, WT % IN SLURRY			SOLIDS, WT % IN SLURRY		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
806-1B	1816	6.22	5.50	6.86	32.98	24.13	36.19	8.49	4.21	20.31	43.07	41.42	44.15	0.66	0.64	0.68	14.5	13.9	15.5
	1825																		
	1851																		
806-1C	1815	0.30	0.05	0.53	0.51	0.01	1.27	21.44	15.37	27.81	16.01	11.63	20.25	6.35	5.74	6.95	14.7	14.0	15.9
	1816	6.54	4.34	9.65	32.09	29.46	35.76	8.55	4.07	12.41	43.09	41.62	45.12	0.25	0.04	0.45	14.2	13.3	15.0
	1825																		
	1851																		
806-1D	1815	1.18	0.76	1.87	6.57	3.07	11.37	16.32	13.76	20.05	19.13	15.16	22.00	3.70	2.53	4.87	14.4	13.6	16.3
	1816	8.52	7.72	9.94	31.88	27.14	35.47	6.58	2.79	11.20	44.16	41.83	45.66	0.43	0.16	0.69	15.9	15.4	16.5
	1825																		
	1851																		
807-1A	1815	1.86	1.10	2.91	22.93	21.29	25.29	5.33	2.20	10.75	26.50	24.21	27.96	4.85	4.20	5.43	14.6	12.9	15.8
	1816	8.63	7.09	11.14	33.74	31.82	36.90	2.26	0.31	4.42	42.29	40.94	44.08	0.55	0.52	0.59	17.1	16.0	17.8
	1825																		
	1851																		
808-1A	1815	0.26	0.05	0.52	0.40	0.17	0.72	25.62	14.92	30.49	19.29	11.46	23.83	5.47	4.94	6.00	15.1	14.3	15.9
	1816	5.10	2.80	7.05	32.77	26.60	38.36	6.50	2.19	13.34	39.73	37.04	41.88	0.49	0.48	0.50	15.5	14.5	16.2
	1825																		
	1851																		
809-1A	1815	0.44	0.00	1.04	0.68	0.18	1.44	39.63	25.24	50.00	28.49	20.71	33.97	0.47	0.20	0.73	14.8	12.9	16.1
	1816	6.51	3.41	9.35	28.34	23.88	33.17	10.56	2.37	23.06	41.68	37.97	49.38	0.08	0.02	0.13	7.9	7.3	8.4
	1825																		
	1851																		
810-1A	1815	1.12	0.09	3.80	0.81	0.14	2.20	41.91	33.75	65.77	31.59	27.14	45.85	0.53	0.28	0.98	14.9	12.2	17.5
	1816	8.19	3.02	12.98	27.92	23.02	32.93	9.44	2.94	14.04	42.29	37.38	44.94	0.14	0.00	0.26	8.4	6.5	14.6
	1825																		
	1851																		
811-1A	1815	1.04	0.17	2.84	1.27	0.05	9.62	50.29	41.97	65.74	37.18	30.24	49.02	0.68	0.40	1.86	14.7	12.4	16.3
	1816	9.51	5.13	12.18	27.64	22.44	33.29	11.41	4.52	17.96	44.63	40.23	50.00	0.18	0.11	0.40	8.0	6.9	9.1
	1825																		
	1851																		
812-1A	1815	5.54	0.49	11.38	0.87	0.15	2.20	42.55	34.36	67.46	39.02	30.71	58.22	0.60	0.26	1.01	16.3	14.6	19.5
	1816	17.96	9.84	27.08	21.89	14.54	29.31	9.14	3.12	13.56	47.71	42.70	51.80	0.07	0.03	0.10	6.9	5.6	10.1
	1825																		
	1851																		
813-1A	1815	5.59	5.59	5.59	2.02	2.02	2.02	37.83	37.83	37.83	36.88	36.88	36.88				13.9	13.9	13.9
	1816	14.27	14.27	14.27	24.40	24.40	24.40	12.06	12.06	12.06	46.90	46.90	46.90				6.3	6.3	6.3
	1825																		
	1851																		
814-1A	1815	4.13	1.07	8.93	0.53	0.00	1.80	40.31	34.58	51.93	33.30	28.37	39.58	0.31	0.25	0.37	14.6	12.4	15.9
	1816	15.16	6.06	24.42	33.56	18.09	28.61	11.05	4.83	24.82	46.69	42.25	57.99	0.11	0.07	0.16	8.2	6.1	9.2
	1825																		
	1851																		

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PERCENT SULFITE OXIDATION AVG	MIN	MAX	STOICHIOMETRIC RATIO AVG	MIN	MAX	PERCENT IONIC IMBALANCE AVG	MIN	MAX
806-1B	1816	17.1	8.5	40.2	1.23	1.20	1.25	0.7	-1.3	3.9
	1825									
	1851									
806-1C	1815	96.9	91.4	99.9	1.03	1.00	1.05	0.9	-4.4	3.8
	1816	17.3	9.5	25.2	1.25	1.15	1.41	1.5	-1.9	7.8
	1825									
	1851									
806-1D	1815	67.5	50.1	83.7	1.09	1.05	1.14	2.3	-2.1	5.0
	1816	14.2	6.2	22.5	1.33	1.29	1.40	1.8	-1.1	5.8
	1825									
	1851									
807-1A	1815	15.4	6.5	28.4	1.10	1.06	1.16	1.3	-5.8	6.5
	1816	5.0	0.7	9.3	1.36	1.27	1.49	0.4	-4.4	5.4
	1825									
	1851									
808-1A	1815	97.8	94.3	99.3	1.02	1.00	1.03	3.1	-0.9	8.4
	1816	13.7	5.1	27.7	1.20	1.09	1.30		-2.0	2.3
	1825									
	1851									
809-1A	1815	97.8	93.3	99.4	1.02	1.00	1.06	-1.5	-7.9	6.1
	1816	21.7	5.8	37.2	1.27	1.10	1.50	2.9	-2.8	8.4
	1825									
	1851									
810-1A	1815	97.6	92.5	99.6	1.05	1.00	1.18	0.1	-7.7	7.2
	1816	21.1	8.3	30.6	1.35	1.13	1.67	1.9	-7.7	8.2
	1825									
	1851									
811-1A	1815	97.2	78.9	99.9	1.04	1.01	1.09	-1.5	-8.2	4.5
	1816	24.4	13.9	37.4	1.39	1.17	1.66	0.8	-7.1	6.9
	1825									
	1851									
812-1A	1815	97.6	94.4	99.5	1.24	1.02	1.46	3.5	-6.4	8.4
	1816	24.9	9.3	37.3	1.96	1.37	2.70	-1.6	-8.4	5.5
	1825									
	1851									
813-1A	1815	93.7	93.7	93.7	1.25	1.25	1.25	4.0	4.0	4.0
	1816	28.3	28.3	28.3	1.61	1.61	1.61	-2.3	-2.3	-2.3
	1825									
	1851									
814-1A	1815	98.4	95.1	100.0	1.19	1.05	1.41	-2.1	-8.0	6.6
	1816	28.0	12.8	46.0	1.74	1.19	2.39	-2.1	-8.2	8.4
	1825									
	1851									

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

RUN NO.	ANALYTICAL POINT	CO2			SO2			SO3			CAO			ACID INSOLUBLES, WT % IN SLURRY			SOLIDS, WT % IN SLURRY		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
815-1A	1815	8.29	1.33	20.24	0.89	0.08	3.61	33.80	20.17	43.53	35.21	30.00	41.19	0.61	0.32	1.34	14.8	12.8	17.0
	1816	16.46	6.01	23.84	20.18	12.97	28.98	8.18	0.22	16.78	44.95	39.43	50.29	0.18	0.07	0.40	8.4	6.0	9.9
	1825																		
	1851																		
816-1A	1815	4.36	1.40	9.66	0.70	0.08	2.17	38.87	33.79	43.25	33.41	30.53	36.51	0.57	0.26	0.77	14.8	13.2	16.6
	1816	13.13	4.51	16.74	22.17	19.18	27.87	10.06	6.57	17.02	43.42	39.02	45.62	0.19	0.15	0.29	7.8	5.0	9.5
	1825																		
	1851																		
817-1A	1815	2.61	1.48	4.23	0.51	0.04	1.35	22.49	11.00	29.12	19.56	10.84	23.99	6.67	5.00	13.55	16.0	14.5	19.4
	1816	12.45	9.66	15.32	24.33	19.67	28.04	7.82	3.52	14.05	42.77	40.99	45.75	0.56	0.40	0.84	8.9	7.8	9.8
	1825																		
	1851																		
818-1A	1815	3.18	1.67	5.42	0.43	0.08	0.86	26.71	21.12	31.15	23.34	20.03	26.68	4.88	3.17	7.20	14.9	13.7	16.0
	1816	12.98	5.94	16.92	23.69	15.61	31.70	7.52	3.95	11.53	42.73	38.85	45.75	0.49	0.34	0.69	9.5	8.6	10.9
	1825																		
	1851																		
819-1A	1815	3.41	0.86	8.71	0.48	0.00	3.32	26.34	13.15	36.37	23.39	16.45	28.87	4.55	1.92	8.67	15.0	11.8	17.4
	1816	13.12	7.53	20.54	23.59	16.28	30.10	7.70	1.95	15.18	43.36	39.81	46.31	0.49	0.15	1.01	10.0	7.1	13.0
	1825																		
	1851																		
819-1B	1815	2.90	1.92	4.48	0.41	0.17	1.21	25.16	18.43	29.73	22.26	17.69	25.07	4.99	2.89	8.01	15.2	13.5	16.7
	1816	12.78	9.49	15.79	23.87	20.26	28.68	6.89	4.71	11.41	42.55	40.96	44.32	0.50	0.37	0.73	9.6	8.5	10.5
	1825																		
	1851																		
820-1A	1815	1.19	0.10	3.96	0.38	0.08	2.08	25.26	19.51	30.35	19.88	13.65	26.86	5.60	3.22	9.77	14.7	11.4	18.8
	1816	11.59	2.42	19.02	20.49	14.88	31.85	10.76	3.82	19.15	39.29	35.11	44.77	0.51	0.04	0.65	5.8	2.2	8.5
	1825																		
	1851																		
820-1B	1815	1.87	1.10	2.72	1.62	0.08	4.56	23.68	17.96	28.41	20.14	15.43	24.13	5.75	4.36	7.89	14.6	11.3	18.7
	1816	11.36	6.67	16.16	24.82	18.83	29.66	6.47	2.33	10.30	40.56	38.90	42.11	0.60	0.50	0.70	8.3	7.5	9.6
	1851																		
820-1C	1815	4.46	3.02	6.12	15.13	12.12	19.03	10.45	7.85	13.40	25.23	22.38	28.86	5.70	4.53	6.98	15.2	13.9	17.6
	1816	11.92	8.78	14.46	24.80	22.80	27.58	7.73	3.69	10.52	41.57	39.84	42.53	0.73	0.64	0.80	10.5	9.4	11.7
	1825																		
	1851																		
821-1A	1815	2.47	2.47	2.47	0.09	0.09	0.09	14.99	14.99	14.99	13.36	13.36	13.36	9.28	9.28	9.28	16.3	16.3	16.3
	1825																		
	1851																		
822-1A	1815	3.28	0.20	10.40	1.18	0.20	12.00	21.00	6.90	29.33	19.28	10.40	27.30	6.42	4.80	8.40	14.4	12.0	17.9
	1816	13.92	7.00	24.60	22.61	12.50	28.90	7.65	3.38	17.70	41.59	39.60	45.90	0.58	0.50	0.70	7.9	6.5	10.3
	1825																		
	1851																		
822-1B	1815	1.11	0.10	4.00	0.45	0.20	1.10	22.19	18.45	26.28	16.67	12.70	19.90	6.23	4.30	8.90	13.3	10.3	15.2

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

		PERCENT SULFITE OXIDATION			STOICHIOMETRIC RATIO			PERCENT IONIC IMBALANCE		
RUN NO.	ANALYTICAL POINT	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
815-1A	1815	96.7	87.8	99.7	1.49	1.06	2.66	0.4	-8.3	6.7
	1816	24.5	0.7	42.0	1.98	1.23	2.81	1.3	-7.6	6.4
	1825									
	1851									
816-1A	1815	97.8	92.8	99.8	1.21	1.06	1.51	-0.1	-7.3	5.9
	1816	26.4	17.9	37.7	1.65	1.17	1.89	0.4	-6.5	7.0
	1825									
	1851									
817-1A	1815	96.7	90.7	99.8	1.23	1.09	1.46	-0.1	-8.2	7.8
	1816	20.4	9.8	34.8	1.60	1.44	1.85	0.2	-8.5	7.8
	1825									
	1851									
818-1A	1815	98.1	96.5	99.7	1.22	1.11	1.40	0.7	-6.7	7.1
	1816	20.7	10.1	35.8	1.65	1.25	2.00	0.3	-6.9	7.0
	1825									
	1851									
819-1A	1815	97.7	85.9	100.0	1.24	1.05	2.10	0.7	-8.1	7.8
	1816	20.7	6.2	40.6	1.66	1.31	2.17	1.3	-7.2	7.2
	1825									
	1851									
819-1B	1815	98.0	93.5	99.2	1.21	1.12	1.43	2.5	-6.9	8.1
	1816	18.8	13.9	31.1	1.64	1.41	1.80	1.3	-5.7	7.2
	1825									
	1851									
820-1A	1815	98.1	88.2	99.6	1.08	1.01	1.26	1.1	-7.1	8.2
	1816	29.7	11.9	50.7	1.63	1.09	2.24	-2.5	-8.3	5.8
	1825									
	1851									
820-1B	1815	92.3	79.1	99.5	1.13	1.07	1.19	-1.4	-8.1	8.3
	1816	17.3	6.4	26.0	1.57	1.30	1.95	-0.4	-8.1	7.2
	1851									
820-1C	1815	35.8	27.8	46.9	1.28	1.19	1.39	-4.0	-8.0	3.1
	1816	19.8	10.2	26.1	1.56	1.40	1.75	-1.8	-8.5	7.0
	1825									
	1851									
821-1A	1815	99.3	99.3	99.3	1.30	1.30	1.30	-2.7	-2.7	-2.7
	1825									
	1851									
822-1A	1815	93.1	31.5	99.0	1.27	1.01	1.86	-3.5	-8.0	4.5
	1816	21.0	11.6	38.7	1.83	1.29	3.10	-3.1	-7.8	6.5
	1825									
	1851									
822-1B	1815	97.6	93.8	98.8	1.09	1.01	1.33	-4.3	-8.3	3.4

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

RUN NO.	ANALYTICAL POINT	CO2			SO2			SO3			CAO			ACID INSOLUBLES, WT % IN SLURRY			SOLIDS, WT % IN SLURRY		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
822-1B	1816	12.46	9.20	15.70	22.09	18.10	26.40	8.12	3.40	13.90	40.30	37.90	42.90	0.43	0.30	0.70	5.6	4.6	7.6
	1825																		
	1851																		
823-1A	1805	13.67	7.40	20.50	0.32	0.20	0.50	14.98	7.38	20.35	28.61	24.40	32.80	4.90	3.50	8.30	15.4	13.4	18.1
	1816	15.29	7.70	19.20	1.51	0.40	3.20	11.69	6.65	16.80	29.06	23.70	33.90	4.38	3.00	5.80	13.3	10.6	15.6
	1825																		
	1851																		
824-1A	1805	9.58	6.10	14.40	0.35	0.10	0.70	15.48	4.45	24.95	23.14	14.70	26.90	8.02	4.90	14.10	19.7	15.4	21.5
	1816	10.74	7.60	15.90	7.46	2.90	10.70	8.67	4.33	12.10	25.83	22.80	28.50	5.49	4.70	6.80	14.1	12.9	16.5
	1825																		
	1851																		
825-1A	1805	6.44	3.10	10.80	0.44	0.10	1.30	21.23	8.58	28.85	22.85	15.80	27.60	6.22	3.40	10.20	16.3	10.1	22.1
	1816	6.71	3.30	10.90	13.44	8.00	17.70	10.79	7.48	16.70	27.43	24.60	31.90	5.05	4.30	5.80	14.7	13.3	16.1
	1825																		
	1851																		
826-1A	1805	8.52	2.20	15.80	0.62	0.10	3.10	19.58	8.18	28.05	24.63	16.30	29.20	5.75	4.30	13.30	16.2	12.1	23.6
	1816	8.06	3.90	13.20	15.25	10.00	22.60	7.67	3.75	12.90	28.65	22.40	32.10	5.07	3.80	6.20	15.2	12.8	17.7
	1825																		
	1851																		
851-1A	1815	0.24	0.11	0.51	0.54	0.36	0.73	22.18	17.46	28.52	17.30	13.74	22.13	6.07	5.70	6.44	15.2	13.9	16.5
	1816	3.65	3.14	4.41	35.12	30.89	39.05	7.26	3.37	14.68	43.29	41.28	45.41	0.35	0.11	0.73	5.9	5.6	6.3
	1825																		
	1851																		
852-1A	1815	0.57	0.11	1.78	3.34	0.01	15.91	19.65	10.12	32.98	18.42	9.16	25.99	5.89	5.85	5.92	15.6	11.5	17.7
	1816	3.28	2.86	4.23	35.67	33.66	36.91	6.73	2.71	12.99	42.66	37.95	44.63	0.39	0.37	0.42	9.1	6.4	10.6
	1825																		
	1851																		
853-1A	1815	0.46	0.15	1.87	0.66	0.01	1.38	21.47	10.12	32.80	17.05	8.88	24.76	8.59	6.12	11.63	15.4	12.9	17.0
	1816	3.76	2.93	4.95	35.39	26.06	37.30	8.95	3.53	28.09	44.24	41.26	51.65	0.37	0.19	0.93	6.2	5.2	7.2
	1825																		
	1851																		
854-1A	1815	0.31	0.05	1.15	0.64	0.07	2.53	21.27	8.38	32.98	16.01	6.13	24.27	7.05	5.32	8.76	15.1	12.4	16.9
	1816	4.11	3.47	4.79	35.80	31.39	39.09	6.19	2.28	12.22	42.85	40.96	44.43	0.14	0.12	0.19	6.1	5.3	7.8
	1825																		
	1851																		
855-1A	1815	0.30	0.04	0.65	0.57	0.15	1.08	48.64	45.53	57.61	34.73	31.62	42.74	0.93	0.32	1.53	14.7	12.3	16.8
	1816	3.95	1.82	5.28	35.07	31.03	36.71	9.41	3.23	13.60	42.06	40.29	43.66	0.05	0.00	0.09	7.2	6.7	8.4
	1825																		
	1851																		
856-1A	1815	0.29	0.00	1.02	0.72	0.24	2.21	35.58	25.96	50.74	26.05	20.83	39.49	1.58	0.11	8.08	15.3	12.5	16.7
	1816	4.39	3.77	5.80	35.82	32.91	37.24	6.28	3.08	12.42	42.46	38.52	44.71	0.24	0.02	0.77	7.8	7.1	8.2
	1825																		
	1851																		

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PERCENT SULFITE OXIDATION			STOICHIOMETRIC RATIO			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
822-1B	1816	22.5	10.8	34.8	1.65	1.45	1.91	-1.6	-7.4	4.9
	1825									
	1851									
823-1A	1805	97.2	92.2	98.8	2.90	1.65	5.66	1.5	-3.4	8.0
	1816	86.1	73.3	95.1	3.17	1.79	4.39	0.3	-5.9	7.2
	1825									
	1851									
824-1A	1805	96.2	84.4	99.0	2.79	1.44	6.57	-0.9	-6.9	3.7
	1816	48.6	24.4	75.7	2.12	1.71	2.94	-1.8	-7.7	5.1
	1825									
	1851									
825-1A	1805	97.3	88.1	99.5	1.63	1.20	3.13	-2.5	-7.3	6.8
	1816	39.4	25.3	62.6	1.45	1.22	1.79	-1.5	-8.0	8.1
	1825									
	1851									
826-1A	1805	96.0	82.2	99.5	1.93	1.18	4.27	-2.0	-8.2	7.7
	1816	28.8	11.7	48.9	1.58	1.25	2.23	-1.3	-8.5	6.5
	1825									
	1851									
851-1A	1815	97.0	95.2	97.9	1.02	1.01	1.03	5.8	3.9	8.4
	1816	14.1	6.9	27.6	1.13	1.10	1.17	6.5	3.3	7.7
	1825									
	1851									
852-1A	1815	84.8	36.1	99.9	1.04	1.02	1.10	5.4	1.6	7.4
	1816	12.9	5.9	23.6	1.12	1.10	1.16	6.0	3.6	8.2
	1825									
	1851									
853-1A	1815	96.2	92.6	99.9	1.05	1.01	1.19	5.1	1.1	7.5
	1816	16.3	7.0	38.8	1.13	1.10	1.19	5.1	-8.3	8.5
	1825									
	1851									
854-1A	1815	96.2	86.0	99.4	1.03	1.00	1.09	0.6	-7.2	6.1
	1816	12.0	4.8	23.7	1.15	1.13	1.18	4.5	-0.2	7.8
	1825									
	1851									
855-1A	1815	98.5	97.2	99.6	1.01	1.00	1.02	-0.8	-5.2	6.0
	1816	17.6	6.8	26.0	1.14	1.06	1.18	-0.7	-7.9	7.5
	1825									
	1851									
856-1A	1815	97.5	94.8	99.1	1.01	1.00	1.05	0.6	-5.2	7.7
	1816	12.2	6.3	22.5	1.16	1.13	1.20	2.5	-6.2	7.9
	1825									
	1851									

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

RUN NO.	ANALYTICAL POINT	CO2			SO2			SO3			CAO			ACID INSOLUBLES, WT % IN SLURRY			SOLIDS, WT % IN SLURRY		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
857-1A	1815	0.07	0.00	0.27	0.91	0.19	3.25	37.65	24.66	53.50	27.58	18.81	38.73	0.68	0.18	1.32	14.8	10.0	18.2
	1816	3.64	2.81	4.12	35.50	33.19	38.04	5.28	1.92	10.41	41.95	40.69	43.78	0.05	0.03	0.08	7.7	7.2	8.6
	1825																		
	1851																		
858-1A	1815	0.45	0.00	1.45	0.63	0.00	2.15	36.33	28.07	54.10	26.24	19.87	39.39	0.21	0.08	0.39	7.7	6.5	8.8
	1816	3.52	3.02	4.21	36.56	31.53	39.09	7.49	2.11	24.26	43.50	41.59	48.86	0.09	0.02	0.18	15.3	13.3	16.7
	1825																		
	1851																		
859-1A	1815	0.95	0.35	1.87	8.15	3.86	11.40	36.07	25.41	54.94	34.34	26.10	40.87	0.11	0.05	0.19	14.1	12.6	15.6
	1816	4.43	3.13	4.95	37.67	34.74	39.55	4.88	1.04	15.65	43.75	41.67	47.07	0.11	0.02	0.20	7.2	6.8	7.6
	1825																		
	1851																		
859-1B	1815	0.17	0.00	0.46	0.51	0.00	1.64	43.75	29.95	57.72	32.28	21.94	40.40	0.39	0.28	0.49	14.6	13.7	16.1
	1816	4.24	3.47	5.11	34.75	34.02	35.83	6.32	2.57	9.45	42.86	42.14	43.68	0.08	0.02	0.14	7.6	7.3	7.8
	1825																		
	1851																		
859-1C	1815	1.04	0.36	1.60	10.95	4.34	15.20	29.63	23.13	42.69	31.33	21.63	40.61	0.34	0.07	0.55	15.2	12.9	16.8
	1816	4.33	3.57	5.34	34.83	32.21	36.94	11.13	7.05	14.32	43.77	42.48	44.99	0.22	0.03	0.30	7.3	6.9	7.7
	1825																		
	1851																		
859-1D	1815	2.95	2.25	4.15	28.24	23.16	31.74	16.68	10.76	24.70	41.42	38.25	43.18	0.32	0.29	0.35	14.2	13.8	14.6
	1816	4.89	3.96	5.55	37.87	36.19	39.45	5.34	1.43	9.91	44.69	40.54	47.39	0.03	0.02	0.03	7.1	6.6	7.5
	1825																		
	1851																		
860-1A	1815	0.20	0.00	0.88	0.65	0.00	1.80	47.07	27.50	69.82	33.88	20.36	49.23	0.40	0.25	0.56	15.5	12.4	26.7
	1816	5.05	4.67	5.44	36.54	34.56	38.47	5.15	2.17	10.97	44.16	40.68	45.21	0.05	0.02	0.08	7.0	6.3	7.7
	1825																		
	1851																		
861-1A	1815	0.21	0.00	0.44	0.65	0.06	2.17	44.14	43.16	45.27	31.93	31.01	33.29	0.22	0.02	0.32	14.3	13.3	16.5
	1816	4.41	3.14	5.80	33.92	29.68	36.39	9.36	5.50	17.04	42.39	41.17	44.02	0.06	0.01	0.16	7.3	7.0	7.9
	1825																		
	1851																		
862-1A	1815	0.29	0.00	0.91	0.50	0.19	1.66	23.37	8.02	28.98	17.04	6.61	20.00	6.35	5.21	10.22	14.9	13.8	15.9
	1816	2.97	2.37	3.65	33.97	31.85	36.54	9.33	6.84	11.80	39.95	38.82	41.34	0.93	0.49	1.52	17.2	12.7	19.7
	1825																		
	1851																		
863-1A	1815	0.26	0.05	2.02	0.74	0.03	6.42	26.49	16.60	34.00	19.78	12.10	25.07	5.23	2.25	8.21	15.3	13.3	17.7
	1816	2.95	1.19	6.49	31.34	25.69	37.60	10.41	2.51	17.83	38.58	34.00	42.11	0.55	0.02	0.84	10.4	8.7	12.1
	1825																		
	1851																		
864-1A	1815	0.19	0.05	0.38	0.31	0.09	0.71	21.40	13.61	27.89	15.48	10.77	19.92	7.33	5.12	9.38	15.9	13.8	17.6
	1816	3.27	2.69	3.86	27.56	25.31	32.42	11.17	8.01	14.01	36.49	34.49	38.56	0.93	0.49	1.20	9.5	9.0	10.1
	1825																		

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PERCENT SULFITE OXIDATION			STOICHIOMETRIC RATIO			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
857-1A	1815	96.9	87.6	99.3	1.00	1.00	1.02	1.2	-6.5	7.6
	1816	10.6	4.0	20.1	1.13	1.10	1.16	6.0	2.1	8.4
	1825									
	1851									
858-1A	1815	97.8	91.5	100.0	1.02	1.00	1.07	-1.5	-7.7	2.5
	1816	13.5	4.1	35.7	1.12	1.09	1.14	4.1	-6.1	7.5
	1825									
	1851									
859-1A	1815	77.2	68.0	91.9	1.04	1.01	1.08	2.1	-5.8	7.8
	1816	9.0	2.1	25.8	1.16	1.11	1.18	3.9	-3.2	7.5
	1825									
	1851									
859-1B	1815	98.6	96.6	100.0	1.01	1.00	1.02	3.2	-3.9	7.0
	1816	12.6	5.4	17.7	1.16	1.12	1.19	6.1	3.1	8.5
	1825									
	1851									
859-1C	1815	68.5	57.4	81.1	1.04	1.02	1.07	-0.7	-7.0	4.8
	1816	20.3	13.5	25.4	1.15	1.13	1.17	-0.1	-7.2	7.2
	1825									
	1851									
859-1D	1815	31.9	22.5	46.0	1.10	1.08	1.14	3.0	-4.3	7.0
	1816	10.0	2.8	17.4	1.17	1.14	1.19	3.5	0.0	6.1
	1825									
	1851									
860-1A	1815	98.3	95.8	100.0	1.01	1.00	1.02	0.2	-7.2	6.4
	1816	10.0	4.4	20.2	1.18	1.16	1.20	4.9	0.9	7.5
	1825									
	1851									
861-1A	1815	98.2	94.1	99.8	1.01	1.00	1.02	0.5	-5.0	3.9
	1816	18.0	11.4	31.5	1.16	1.11	1.20	1.2	-3.3	6.8
	1825									
	1851									
862-1A	1815	97.2	90.9	99.1	1.02	1.00	1.07	-0.8	-7.5	7.7
	1816	18.0	13.8	22.9	1.11	1.09	1.13	-0.3	-5.6	7.6
	1825									
	1851									
863-1A	1815	96.7	72.7	99.8	1.02	1.00	1.16	1.2	-8.4	8.1
	1816	20.9	5.1	35.7	1.11	1.04	1.25	0.2	-8.3	7.4
	1825									
	1851									
864-1A	1815	98.1	94.8	99.6	1.02	1.00	1.03	-0.1	-5.7	5.6
	1816	24.5	18.4	30.1	1.13	1.10	1.16	1.0	-5.2	7.4
	1825									

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

RUN NO.	ANALYTICAL POINT	CO2 AVG	CO2 MIN	CO2 MAX	SO2 AVG	SO2 MIN	SO2 MAX	SO3 AVG	SO3 MIN	SO3 MAX	CAO AVG	CAO MIN	CAO MAX	ACID INSOLUBLES, WT % IN SLURRY AVG	ACID INSOLUBLES, WT % IN SLURRY MIN	ACID INSOLUBLES, WT % IN SLURRY MAX	SOLIDS, WT % IN SLURRY AVG	SOLIDS, WT % IN SLURRY MIN	SOLIDS, WT % IN SLURRY MAX
864-1A	1851																		
865-1A	1815	0.30	0.11	0.60	2.50	0.36	9.41	22.56	16.37	28.36	18.69	13.64	21.96	5.92	4.23	8.51	15.4	13.7	17.2
	1816	2.59	1.86	3.59	28.04	23.88	31.85	12.45	9.02	16.34	36.47	35.37	38.03	0.88	0.58	1.64	10.1	8.6	12.2
	1825																		
	1851																		
866-1A	1815	0.34	0.11	0.88	2.36	0.08	10.04	24.87	20.71	33.97	19.95	15.60	24.62	4.93	2.51	7.03	15.5	14.2	16.9
	1816	3.39	1.32	6.44	27.35	23.52	31.49	11.50	7.85	15.83	36.45	33.36	38.28	0.77	0.53	1.10	9.9	8.7	11.1
	1825																		
	1851																		
867-1A	1815	0.19	0.08	0.43	0.38	0.08	1.07	28.78	23.46	31.85	21.43	16.09	23.95	4.31	3.03	5.74	14.5	12.9	15.6
	1816	3.05	2.31	4.12	30.85	28.10	33.66	9.53	6.66	12.25	37.29	35.81	39.59	0.75	0.50	0.95	11.7	7.9	14.6
	1825																		
	1851																		

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PERCENT SULFITE OXIDATION			STOICHIOMETRIC RATIO			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
864-1A	1851									
865-1A	1815	87.8	59.9	98.4	1.02	1.01	1.04	1.7	-6.1	6.6
	1816	26.3	18.5	35.0	1.10	1.07	1.14	-0.3	-4.0	4.4
	1825									
	1851									
866-1A	1815	90.4	62.9	99.5	1.02	1.01	1.05	0.2	-7.6	6.3
	1816	25.2	16.7	32.1	1.14	1.05	1.28	0.3	-7.3	5.8
	1825									
	1851									
867-1A	1815	98.4	96.0	99.7	1.01	1.01	1.03	3.0	-4.4	7.6
	1816	19.8	14.1	25.9	1.12	1.09	1.17	-0.8	-6.7	3.5
	1825									
	1851									

TCA RUN DEFINITION

RUN NO.	RUN REP FLAG	START DATE	START TIME	END DATE	END TIME	HOURS ON STRM	FACT OR TIME	RUN COMMENTS
TFG-2A	N/A	02/28/77	1330	03/03/77	1807	76	T	N/A
TFG-2B	N/A	02/04/77	0530	02/10/77	0530	128	T	N/A
TFG-2C	N/A	02/10/77	1310	02/14/77	1025	93	T	N/A
TFG-2D	N/A	02/15/77	1730	02/19/77	1505	93	T	N/A
TFG-2E	N/A	02/19/77	1505	02/23/77	1515	96	T	N/A
TFG-2F	N/A	02/23/77	1515	02/28/77	0750	112	T	N/A
525-2A	N/A	10/24/73	1600	11/15/73	0500	517	T	N/A
526-2A	N/A	11/21/73	1800	01/10/74	0800	1190	T	N/A
527-2A	N/A	01/18/74	1800	01/24/74	0700	133	T	N/A
528-2A	N/A	02/06/74	2300	02/26/74	0800	425	T	N/A
529-2A	N/A	02/26/74	1300	03/07/74	1000	213	T	N/A
530-2A	N/A	03/28/74	1100	04/17/74	1200	476	T	N/A
531-2A	N/A	05/10/74	1000	06/26/74	0700	1088	T	STEADY STATE NOT ACHIEVED
532-2A	N/A	07/17/74	1600	07/29/74	0800	258	T	N/A
533-2A	N/A	08/06/74	1700	08/21/74	1100	332	T	N/A
534-2A	N/A	09/03/74	1400	09/08/74	2100	100	T	N/A
535-2A	N/A	09/12/74	1700	12/04/74	1100	1835	T	N/A
535-2B	N/A	12/04/74	1100	12/30/74	0700	490	T	N/A
536-2A	N/A	12/31/74	2000	01/15/75	0800	328	T	N/A
537-2A	N/A	01/15/75	1600	01/21/75	0900	137	T	N/A
538-2A	N/A	01/24/75	1600	02/21/75	0500	562	T	N/A
539-2A	N/A	03/07/75	1700	03/21/75	1300	278	T	N/A
540-2A	N/A	03/21/75	1700	03/25/75	1200	90	T	N/A
541-2A	N/A	03/25/75	1500	03/28/75	0900	65	T	N/A
542-2A	N/A	03/28/75	1400	04/01/75	0900	91	T	N/A
543-2A	N/A	04/01/75	0900	04/03/75	0800	47	T	AIR PURPOSELY INTRODUCED INTO SYSTEM TO DETERMINE EFFECT ON OXIDATION
544-2A	N/A	04/04/75	1100	04/15/75	0800	269	T	N/A
545-2A	N/A	04/15/75	1100	04/21/75	0700	133	T	N/A
546-2A	N/A	06/08/75	2300	06/17/75	0700	207	T	N/A
547-2A	N/A	06/18/75	1500	06/23/75	0700	112	T	N/A
548-2A	N/A	06/23/75	2000	06/27/75	0700	71	T	N/A
549-2A	N/A	06/27/75	1600	07/02/75	0700	112	T	N/A
550-2A	N/A	07/02/75	1600	07/08/75	0700	119	T	N/A
551-2A	N/A	07/08/75	1500	07/10/75	0500	39	T	N/A
552-2A	N/A	07/10/75	1700	07/14/75	0700	86	T	N/A
553-2A	N/A	07/19/75	1600	07/21/75	1000	42	T	N/A
554-2A	N/A	07/25/75	1900	07/28/75	0700	60	T	N/A
555-2A	N/A	07/29/75	1600	08/01/75	0700	63	T	N/A
556-2A	N/A	08/01/75	1400	08/05/75	0700	89	T	N/A
557-2A	N/A	08/05/75	1700	08/13/75	0600	181	T	N/A
558-2A	N/A	08/15/75	1400	09/02/75	0700	398	T	N/A
559-2A	N/A	09/05/75	1400	09/22/75	0500	384	T	N/A
560-2A	N/A	09/23/75	1000	09/29/75	0700	142	T	N/A
561-2A	N/A	09/30/75	1700	10/06/75	0700	135	T	N/A

TCA RUN DEFINITION

RUN NO.	RUN REP FLAG	START DATE	START TIME	END DATE	END TIME	HOURS ON STRM	FACT OR TIME	RUN COMMENTS
562-2A	N/A	10/06/75	1500	10/30/75	0700	495	T	N/A
562-2B	N/A	10/30/75	1500	11/06/75	0700	134	T	N/A
563-2A	N/A	11/06/75	1300	11/14/75	0700	182	T	N/A
564-2A	N/A	11/14/75	1500	11/19/75	0700	113	T	N/A
565-2A	N/A	11/21/75	1900	11/26/75	0700	109	T	N/A
566-2A	N/A	11/26/75	1400	12/03/75	1100	166	T	N/A
567-2A	N/A	12/03/75	1400	12/09/75	0700	138	T	N/A
568-2A	N/A	12/09/75	1400	12/16/75	0700	162	T	N/A
569-2A	N/A	12/16/75	1500	12/19/75	0800	66	T	N/A
569-2B	N/A	12/19/75	1300	12/23/75	0800	97	T	N/A
570-2A	N/A	12/23/75	1000	12/29/75	0900	144	T	N/A
571-2A	N/A	12/29/75	1100	01/02/76	1000	96	T	N/A
571-2B	N/A	01/02/76	1100	01/02/76	2100	11	T	THIS IS AN ABSORBENT DEPLETION RUN
572-2A	N/A	01/02/76	2200	01/09/76	0800	154	T	N/A
573-2A	N/A	01/09/76	0800	01/11/76	0400	45	T	N/A
575-2A	N/A	01/15/76	1400	01/17/76	1200	47	T	N/A
576-2A	N/A	01/17/76	1300	01/22/76	0400	112	T	N/A
576-2B	N/A	01/22/76	0400	01/22/76	0600	3	T	THIS IS AN ABSORBENT DEPLETION RUN
577-2A	N/A	01/22/76	1700	01/29/76	0700	159	T	N/A
578-2A	N/A	01/29/76	1300	01/29/76	2100	9	T	THIS IS AN ABSORBENT DEPLETION RUN
579-2A	N/A	01/29/76	2200	02/01/76	1200	62	T	N/A
580-2A	N/A	02/01/76	1200	02/01/76	2300	12	T	THIS IS AN ABSORBENT DEPLETION RUN
581-2A	N/A	02/04/76	1700	02/11/76	1400	164	T	N/A
582-2A	N/A	02/11/76	1400	02/12/76	0700	18	T	THIS IS AN ABSORBENT DEPLETION RUN
583-2A	N/A	04/15/76	1745	04/21/76	0500	131	T	SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION
583-2B	N/A	04/21/76	1545	05/01/76	1100	230	T	SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION
584-2A	N/A	05/03/76	2145	05/14/76	0800	236	T	N/A
585-2A	N/A	05/14/76	1145	05/20/76	0745	140	T	SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION
586-2A	N/A	05/20/76	1300	05/25/76	0500	110	T	N/A
587-2A	N/A	05/31/76	1445	06/14/76	0530	295	T	N/A
588-2A	N/A	06/16/76	0945	06/21/76	0115	107	T	N/A
589-2A	N/A	06/21/76	1515	07/01/76	0515	200	T	N/A
590-2A	N/A	01/24/78	1347	01/26/78	1010	45	T	N/A
590-2B	N/A	02/02/78	1255	02/06/78	0900	92	T	N/A
591-2A	N/A	03/27/78	1345	04/05/78	1220	207	T	N/A
592-2A	7	04/05/78	1220	04/21/78	0730	293	T	N/A
593-2A	N/A	04/21/78	1135	05/02/78	0825	260	T	N/A
594-2A	7	05/02/78	1710	05/06/78	1955	99	T	N/A
601-2A	N/A	07/01/76	2045	07/12/76	0545	177	T	N/A
602-2A	N/A	07/12/76	1630	07/18/76	1210	137	T	N/A
603-2A	N/A	07/19/76	2330	07/26/76	2035	165	T	N/A
604-2A	N/A	07/28/76	1600	08/04/76	0538	158	T	SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION
605-2A	N/A	08/05/76	2115	08/13/76	1235	170	T	N/A
606-2A	N/A	08/13/76	1245	08/18/76	1416	122	T	SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION

TCA RUN DEFINITION

RUN NO.	RUN REP FLAG	START DATE	START TIME	END DATE	END TIME	HOURS ON STRM	FACT OR TIME	RUN COMMENTS
607-2A	N/A	08/19/76	1427	09/02/76	1645	212	T	SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION
608-2A	N/A	09/03/76	1235	09/06/76	2250	84	T	SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION
608-2B	N/A	09/06/76	2250	09/13/76	0715	151	T	N/A
609-2A	N/A	09/13/76	1045	09/24/76	0300	259	T	N/A
610-2A	N/A	09/24/76	1100	10/07/76	1350	280	T	N/A
611-2A	N/A	10/07/76	1600	10/12/76	0500	111	T	SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION
612-2A	N/A	10/12/76	1433	10/18/76	0905	138	T	SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION
613-2A	N/A	10/18/76	1604	10/21/76	1110	67	T	SUSPECTED AIR LEAK VIA DOWNCOMER INTO D-204 EHT CAUSED HIGH OXIDATION
614-2A	N/A	10/22/76	1356	10/28/76	0845	139	T	N/A
615-2A	N/A	10/28/76	1300	11/03/76	1213	110	T	N/A
616-2A	N/A	11/05/76	0800	11/13/76	1000	174	T	N/A
617-2A	N/A	11/15/76	1705	11/22/76	0825	158	T	N/A
618-2A	N/A	02/06/78	0900	02/13/78	1240	162	T	N/A
618-2B	N/A	02/13/78	1240	02/17/78	0735	88	T	N/A
619-2A	7	02/17/78	1400	03/02/78	0815	306	T	N/A
620-2A	N/A	03/02/78	1200	03/06/78	2145	106	T	N/A
621-2A	7	03/17/78	0935	03/27/78	0810	239	T	N/A
622-2A	7	05/08/78	1830	05/12/78	1400	91	T	N/A
622-2B	N/A	05/12/78	1400	05/19/78	1600	125	T	N/A
623-2A	N/A	05/19/78	1600	05/31/78	0520	271	T	N/A
624-2A	N/A	06/08/78	1235	06/19/78	1735	269	T	N/A
625-2A	N/A	11/10/78	1510	01/25/79	0855	1652	T	N/A
701-2A		11/24/76	1900	12/06/76	0800	277	T	N/A
702-2A	N/A	12/06/76	1500	12/13/76	1300	162	T	N/A
703-2A	N/A	12/13/76	1610	12/20/76	1050	162	T	N/A
704-2A	N/A	12/21/76	2030	01/04/77	0830	324	T	N/A
705-2A	N/A	01/04/77	1210	01/14/77	0812	236	T	N/A
706-2A	N/A	01/14/77	1350	01/04/77	0530	339	T	N/A
707-2A	N/A	03/04/77	1350	03/09/77	0730	113	T	N/A
708-2A	N/A	03/09/77	1450	03/14/77	2400	128	T	N/A
709-2A	N/A	03/15/77	0000	03/17/77	0737	56	T	N/A
710-2A	N/A	03/17/77	1405	03/24/77	0744	162	T	N/A
711-2A	N/A	03/24/77	1349	03/28/77	1135	93	T	N/A
712-2A	N/A	03/28/77	1550	04/02/77	1300	117	T	N/A
713-2A	N/A	06/15/77	1305	06/24/77	1145	202	T	N/A
714-2A	N/A	08/30/77	1200	09/07/77	2020	201	T	N/A
714-2B	N/A	09/07/77	2000	09/09/77	0800	36	T	N/A
715-2A	N/A	10/07/77	1439	10/14/77	0735	161	T	N/A
716-2A	N/A	10/14/77	1300	10/20/77	0325	135	T	N/A
717-2A	N/A	10/20/77	1408	11/21/77	0820	747	T	N/A
718-2A	N/A	11/24/77	1200	11/30/77	0625	143	T	N/A
719-2A	N/A	12/01/77	1705	12/09/77	0755	183	T	N/A
801-2A	N/A	06/24/77	1145	06/28/77	1715	102	T	N/A
801-2B	N/A	06/28/77	1715	06/30/77	1600	47	T	N/A

TCA RUN DEFINITION

RUN NO.	RUN REP FLAG	START DATE	START TIME	END DATE	END TIME	HOURS ON STRM	FACT OR TIME	RUN COMMENTS
802-2A	N/A	07/01/77	1308	07/07/77	1135	142	T	N/A
803-2A	N/A	07/08/77	1401	07/15/77	1042	165	T	N/A
804-2A	N/A	07/15/77	1042	07/22/77	0820	166	T	N/A
805-2A	N/A	07/22/77	1250	07/28/77	0820	140	T	N/A
806-2A	N/A	07/28/77	1305	08/02/77	0800	115	T	N/A
807-2A	N/A	08/02/77	1505	08/10/77	0810	185	T	N/A
808-2A	N/A	08/10/77	1140	08/17/77	0510	162	T	N/A
809-2A	N/A	08/17/77	1525	08/23/77	2050	149	T	N/A
810-2A	N/A	08/24/77	1410	08/29/77	2355	130	T	N/A
811-2A	N/A	09/09/77	1157	09/16/77	0738	164	T	N/A
812-2A	N/A	09/16/77	1010	09/22/77	0735	141	T	SOLIDS SAMPLES ARE BEING RUN BY WET METHOD BEGINNING 0730 ON 9-16-77
813-2A	N/A	09/23/77	2205	09/29/77	0735	130	T	N/A
814-2A	N/A	09/29/77	1000	10/04/77	0910	119	T	N/A
815-2A	N/A	12/09/77	0950	12/14/77	1115	75	T	N/A
816-2A	N/A	12/14/77	1315	12/16/77	1430	48	T	N/A
817-2A	N/A	12/16/77	1430	12/23/77	0740	161	T	N/A
818-2A	N/A	12/23/77	0740	12/30/77	1210	131	T	N/A
818-2B	N/A	12/30/77	1210	01/05/78	0740	140	T	N/A
819-2A	N/A	01/06/78	1401	01/13/78	1200	164	T	N/A
820-2A	N/A	01/13/78	1200	01/24/78	0805	259	T	N/A
821-2A	N/A	05/31/78	1655	06/08/78	0735	182	T	N/A

TCA SYSTEM CONFIGURATION

RUN NO.	TCA NO. BEDS	TCA TOT BED HGT	TCA SPHERE TYPE	NO.OF HOLD TANKS	M.E. SYSTEM CONFIG	M.E. WASH B/T	DE-WATER SYSTEM	OXID CONFIG FLAG	ALK ADDN PT.	RUN NO.
TFG-2A	3	15.0	FOAM	1	1-3P/OV	I/I	CL	N/A	EHT	TFG-2A
TFG-2B	3	15.0	FOAM	3	1-3P/OV	I/I	CL	N/A	EHT	TFG-2B
TFG-2C	3	15.0	FOAM	3	1-3P/OV	C/I	CL	N/A	EHT	TFG-2C
TFG-2D	3	15.0	FOAM	3	1-3P/OV	C/I	CL	N/A	EHT	TFG-2D
TFG-2E	3	15.0	FOAM	3	1-3P/OV	C/I	CL	N/A	EHT	TFG-2E
TFG-2F	3	15.0	FOAM	3	1-3P/OV	C/I	CL	N/A	EHT	TFG-2F
525-2A	3	15.0	H/T	1	KT-6P/C	NONE	CL	N/A	EHT	525-2A
526-2A	3	15.0	HDPE	1	KT-6P/C	NONE	CL	N/A	EHT	526-2A
527-2A	2	15.0	HDPE	1	KT-6P/C	NONE	CL	N/A	EHT	527-2A
528-2A	3	15.0	TPR	1	KT-6P/C	NONE	CL	N/A	EHT	528-2A
529-2A	3	15.0	TPR	1	KT-6P/C	NONE	CL	N/A	EHT	529-2A
530-2A	3	15.0	TPR	1	KT-6P/C	NONE	CL	N/A	EHT	530-2A
531-2A	3	15.0	TPR	1	KT-6P/C	NONE	CL	N/A	EHT	531-2A
532-2A	3	15.0	TPR	1	KT-6P/C	C/	CL	N/A	EHT	532-2A
533-2A	3	15.0	TPR	1	KT-6P/C	C/	CL	N/A	EHT	533-2A
534-2A	3	15.0	TPR	1	KT-6P/C	C/	CL	N/A	EHT	534-2A
535-2A	3	15.0	TPR	1	KT-6P/C	C/	CL	N/A	EHT	535-2A
535-2B	3	15.0	TPR	1	KT-6P/C	C/	CL	N/A	EHT	535-2B
536-2A	3	15.0	TPR	1	KT-6P/C	C/	CL	N/A	EHT	536-2A
537-2A	3	15.0	TPR	1	KT-6P/C	C/	CL	N/A	EHT	537-2A
538-2A	3	15.0	TPR	1	KT-6P/C	C/	CL	N/A	EHT	538-2A
539-2A	3	15.0	HDPE	1	KT-6P/C	C/	CL/F	N/A	EHT	539-2A
540-2A	3	15.0	HDPE	1	KT-6P/C	C/	CL/F	N/A	EHT	540-2A
541-2A	3	15.0	HDPE	1	KT-6P/C	C/	CL/F	N/A	EHT	541-2A
542-2A	3	15.0	HDPE	1	KT-6P/C	C/	CL/F	N/A	EHT	542-2A
543-2A	3	15.0	HDPE	1	KT-6P/C	C/	CL/F	N/A	EHT	543-2A
544-2A	3	15.0	HDPE	1	KT-6P/C	C/	CL	N/A	EHT	544-2A
545-2A	3	15.0	HDPE	1	KT-6P/C	C/	CL/F	N/A	EHT	545-2A
546-2A	3	15.0	TPR	1	2-3P/CV	I/I	CL	N/A	EHT	546-2A
547-2A	3	15.0	TPR	1	2-3P/CV	I/I	CL	N/A	EHT	547-2A
548-2A	3	15.0	TPR	1	2-3P/CV	C/I	CL	N/A	EHT	548-2A
549-2A	3	15.0	TPR	1	2-3P/CV	C/I	CL	N/A	EHT	549-2A
550-2A	3	15.0	TPR	1	2-3P/CV	C/I	CL	N/A	EHT	550-2A
551-2A	3	15.0	TPR	1	2-3P/CV	C/I	CL	N/A	EHT	551-2A
552-2A	3	15.0	TPR	1	2-3P/CV	C/I	CL	N/A	EHT	552-2A
553-2A	3	15.0	TPR	1	1-3P/OV	I/I	CL	N/A	EHT	553-2A
554-2A	3	15.0	TPR	1	1-3P/OV	I/I	CL	N/A	EHT	554-2A
555-2A	3	15.0	TPR	1	1-3P/OV	C/I	CL	N/A	EHT	555-2A
556-2A	3	15.0	TPR	1	1-3P/OV	C/I	CL	N/A	EHT	556-2A
557-2A	3	15.0	TPR	1	1-3P/OV	C/I	CL	N/A	EHT	557-2A
558-2A	3	15.0	TPR	1	1-3P/OV	C/I	CL	N/A	EHT	558-2A
559-2A	3	15.0	TPR	1	1-3P/OV	C/I	CL	N/A	EHT	559-2A
560-2A	3	15.0	TPR	1	1-3P/OV	C/I	CL	N/A	EHT	560-2A
561-2A	3	15.0	TPR	1	1-3P/OV	C/I	CL	N/A	EHT	561-2A

TCA SYSTEM CONFIGURATION

RUN NO.	TCA NO. BEDS	TCA TOT BED HGT	TCA SPHERE TYPE	NO.OF HOLD TANKS	M.E. SYSTEM CONFIG	M.E. WASH B/T	DE-WATER SYSTEM	OXID CONFIG FLAG	ALK ADDN PT.	RUN NO.
562-2A	3	15.0	TPR	1	1-3P/OV	C/I	CL	N/A	EHT	562-2A
562-2B	3	15.0	TPR	1	1-3P/OV	C/I	CL	N/A	EHT	562-2B
563-2A	3	15.0	TPR	1	1-3P/OV	C/I	CL	N/A	EHT	563-2A
564-2A	3	15.0	TPR	1	1-3P/OV	C/I	CL	N/A	EHT	564-2A
565-2A	3	15.0	TPR	3	1-3P/OV	C/I	CL	N/A	EHT	565-2A
566-2A	3	15.0	TPR	3	1-3P/OV	C/I	CL	N/A	EHT	566-2A
567-2A	3	15.0	TPR	3	1-3P/OV	C/I	CL	N/A	EHT	567-2A
568-2A	3	15.0	TPR	3	1-3P/OV	I/I	CL	N/A	EHT	568-2A
569-2A	3	15.0	TPR	3	1-3P/OV	I/I	CL	N/A	EHT	569-2A
569-2B	3	15.0	FOAM	3	1-3P/OV	I/I	CL	N/A	EHT	569-2B
570-2A	3	15.0	FOAM	3	1-3P/OV	I/I	CL	N/A	EHT	570-2A
571-2A	3	15.0	FOAM	3	1-3P/OV	I/I	CL	N/A	EHT	571-2A
571-2B	3	15.0	FOAM	3	1-3P/OV	I/I	CL	N/A	-	571-2B
572-2A	3	15.0	FOAM	3	1-3P/OV	I/I	CL	N/A	EHT	572-2A
573-2A	3	15.0	FOAM	3	1-3P/OV	I/	CL	N/A	EHT	573-2A
575-2A	3	15.0	FOAM	3	1-3P/OV	I/	CL	N/A	EHT	575-2A
576-2A	3	15.0	FOAM	3	1-3P/OV	I/	CL	N/A	EHT	576-2A
576-2B	3	15.0	FOAM	3	1-3P/OV	I/	CL	N/A	-	576-2B
577-2A	3	17.0	FOAM	3	1-3P/OV	I/I	CL	N/A	EHT	577-2A
578-2A	3	17.0	FOAM	3	1-3P/OV	I/I	CL	N/A	-	578-2A
579-2A	3	17.0	FOAM	3	1-3P/OV	I/I	CL	N/A	EHT	579-2A
580-2A	3	17.0	FOAM	3	1-3P/OV	I/I	CL	N/A	-	580-2A
581-2A	3	24.0	FOAM	1	1-3P/OV	I/I	CL	N/A	EHT	581-2A
582-2A	3	24.0	FOAM	1	1-3P/OV	I/I	CL	N/A	-	582-2A
583-2A	3	15.0	FOAM	1	1-3P/OV	I/I	CL	N/A	EHT	583-2A
583-2B	3	14.5	FOAM	1	1-3P/OV	I/I	CL	N/A	EHT	583-2B
584-2A	3	14.0	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	584-2A
585-2A	3	13.5	FOAM	1	1-3P/OV	I/I	CL	N/A	DNC	585-2A
586-2A	3	0.0	N/A	1			CL	N/A	DNC	586-2A
587-2A	3	13.0	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	587-2A
588-2A	3	15.0	FOAM	1	1-3P/OV	I/I	CE	N/A	DNC	588-2A
589-2A	3	15.0	FOAM	1	1-3P/OV	I/I	CE	N/A	DNC	589-2A
590-2A	3	15.0	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	590-2A
590-2B	3	15.0	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	590-2B
591-2A	3	15.0	FOAM	1	1-3P/OV	I/S	CL/CE	N/A	EHT	591-2A
592-2A	3	15.0	FOAM	1	1-3P/OV	I/S	CL/CE	N/A	EHT	592-2A
593-2A	3	15.0	FOAM	1	1-3P/OV	I/S	CL/CE	N/A	EHT	593-2A
594-2A	3	15.0	FOAM	1	1-3P/OV	I/S	CL/CE	N/A	EHT	594-2A
601-2A	3	14.5	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	601-2A
602-2A	3	14.5	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	602-2A
603-2A	3	14.5	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	EHT	603-2A
604-2A	3	14.0	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	604-2A
605-2A	3	14.0	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	605-2A
606-2A	3	14.0	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	606-2A

TCA SYSTEM CONFIGURATION

RUN NO.	TCA NO. BEDS	TCA TOT BED HGT	TCA SPHERE TYPE	NO.OF HOLD TANKS	M.E. SYSTEM CONFIG	M.E. WASH B/T	DE-WATER SYSTEM	OXID CONFIG FLAG	ALK ADDN PT.	RUN NO.
607-2A	3	13.5	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	607-2A
608-2A	3	13.5	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	608-2A
608-2B	3	13.5	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	608-2B
609-2A	3	13.5	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	609-2A
610-2A	3	13.0	FOAM	1	1-3P/OV	I/I	CL/F	N/A	DNC	610-2A
611-2A	3	12.5	FOAM	1	1-3P/OV	I/I	CL/F	N/A	DNC	611-2A
612-2A	3	12.5	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	612-2A
613-2A	3	12.0	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	613-2A
614-2A	3	12.0	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	614-2A
615-2A	3	11.5	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	615-2A
616-2A	3	11.0	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	616-2A
617-2A	3	15.0	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	617-2A
618-2A	3	15.0	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	618-2A
618-2B	3	15.0	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	DNC	618-2B
619-2A	3	15.0	FOAM	1	1-3P/OV	I/S	CL/CE	N/A	DNC	619-2A
620-2A	3	15.0	FOAM	1	1-3P/OV	I/S	CL/CE	N/A	DNC	620-2A
621-2A	3	15.0	FOAM	1	1-3P/OV	I/S	CL/CE	N/A	DNC	621-2A
622-2A	3	15.0	FOAM	1	1-3P/OV	I/S	CL/CE	N/A	EHT	622-2A
622-2B	3	15.0	FOAM	1	1-3P/OV	I/S	CL/CE	N/A	DNC	622-2B
623-2A	3	15.0	FOAM	1	1-3P/OV	I/S	CL/CE	N/A	DNC	623-2A
624-2A	3	15.0	FOAM	1	1-3P/OV	I/S	CL	N/A	DNC	624-2A
625-2A	3	14.0	FOAM	N/A	1-3P/OV	I/S	CL/CE	N/A	DNC	625-2A
701-2A	3	15.0	FOAM	1	1-3P/OV	I/I	CL/CE	N/A	EHT	701-2A
702-2A	3	14.0	FOAM	1	1-3P/OV	I/I	CE	N/A	EHT	702-2A
703-2A	3	15.0	FOAM	1			CL/CE	N/A	EHT	703-2A
704-2A	3	15.0	FOAM	3			CL/CE	N/A	EHT	704-2A
705-2A	3	15.0	FOAM	3			CL	N/A	EHT	705-2A
706-2A	3	15.0	FOAM	3			CL	N/A	EHT	706-2A
707-2A	3	15.0	FOAM	1	1-3P/OV	I/I	CL	N/A	EHT	707-2A
708-2A	3	15.0	FOAM	1	1-3P/OV	I/I	CL	N/A	EHT	708-2A
709-2A	3	15.0	FOAM	1	1-3P/OV	I/I	CL	N/A	EHT	709-2A
710-2A	3	15.0	FOAM	1	1-3P/OV	I/I	CL	N/A	EHT	710-2A
711-2A	3	15.0	FOAM	1	1-3P/OV	I/I	CL	N/A	EHT	711-2A
712-2A	3	15.0	FOAM	3	1-3P/OV	I/I	CL	N/A	EHT	712-2A
713-2A	3	15.0	FOAM	1	1-3P/OV	C/I	CL	N/A	EHT	713-2A
714-2A	3	15.0	FOAM	1	1-3P/OV	C/I	CL	N/A	EHT	714-2A
714-2B	3	15.0	FOAM	1	1-3P/OV	C/S	LAM	N/A	EHT	714-2B
715-2A	3	21.0	FOAM	3	1-3P/OV	C/I	CL	N/A	EHT	715-2A
716-2A	3	30.0	FOAM	3	1-3P/OV	C/I	CL	N/A	EHT	716-2A
717-2A	3	22.5	FOAM	3	1-3P/OV	C/I	CL	N/A	EHT	717-2A
718-2A	N/A	N/A	N/A	1	1-3P/OV	C/I	CL	N/A	EHT	718-2A
719-2A	N/A	N/A	N/A	1	1-3P/OV	I/I	CL	N/A	EHT	719-2A
801-2A	3	15.0	FOAM	1	1-3P/OV	C/I	CL	2	EHT	801-2A
801-2B	3	15.0	FOAM	1	1-3P/OV	C/I	CL	N/A	EHT	801-2B

TCA SYSTEM CONFIGURATION

RUN NO.	TCA NO. BEDS	TCA TOT BED HGT	TCA SPHERE TYPE	NO.OF HOLD TANKS	M.E. SYSTEM CONFIG	M.E. WASH B/T	DE-WATER SYSTEM	OXID CONFIG FLAG	ALK ADDN PT.	RUN NO.
802-2A	3	15.0	FOAM	1	1-3P/OV	C/I	CL	N/A	EHT	802-2A
803-2A	3	15.0	FOAM	1	1-3P/OV	C/I	CL	N/A	EHT	803-2A
804-2A	3	15.0	FOAM	1	1-3P/OV	C/I	CL	N/A	EHT	804-2A
805-2A	3	15.0	FOAM	1	1-3P/OV	C/I	CL	N/A	EHT	805-2A
806-2A	3	15.0	FOAM	1	1-3P/OV	C/I	CL	N/A	EHT	806-2A
807-2A	3	15.0	FOAM	1	1-3P/OV	C/I	CL	3	EHT	807-2A
808-2A	3	15.0	FOAM	2	1-3P/OV	C/I	CL	N/A	EHT	808-2A
809-2A	3	15.0	FOAM	2	1-3P/OV	C/I	CL/F	N/A	EHT	809-2A
810-2A	3	15.0	FOAM	2	1-3P/OV	C/I	CL/F	N/A	EHT	810-2A
811-2A	3	15.0	FOAM	2	1-3P/OV	C/I	CL	N/A	EHT	811-2A
812-2A	3	15.0	FOAM	2	1-3P/OV	C/I	CL	N/A	EHT	812-2A
813-2A	3	15.0	FOAM	1	1-3P/OV	C/I	CL	N/A	EHT	813-2A
814-2A	3	15.0	FOAM	1	1-3P/OV	C/I	CL	N/A	EHT	814-2A
815-2A	3	15.0	FOAM	1	1-3P/OV	C/I	CL	N/A	EHT	815-2A
816-2A	3	22.0	FOAM	1	1-3P/OV	C/I	CL	N/A	EHT	816-2A
817-2A	3	22.0	FOAM	1	1-3P/OV	C/I	CL	N/A	EHT	817-2A
818-2A	3	22.0	FOAM	1	1-3P/OV	C/I	CL	N/A	EHT	818-2A
818-2B	3	22.0	FOAM	1	1-3P/OV	C/I	CL	N/A	EHT	818-2B
819-2A	3	22.0	FOAM	1	1-3P/OV	C/I	CL	N/A	N/A	819-2A
820-2A	3	22.0	FOAM	1	1-3P/OV	C/I	CL	N/A	N/A	820-2A
821-2A	3	15.0	FOAM	1	1-3P/OV	I/S	CL/CE	4	EHT	821-2A

TCA OPERATING CONDITIONS

RUN NO.	ALK TYPE	FLY ASH	MGO	PH CONTR POINT	GAS RATE ACFM	GAS VEL FPS	TCA LIQ RATE GPM	TCA L/G GAL/ MACF	SOLID RECIRC NOM %	SOLIDS DISCH RANGE %	TCA D.P. IN. H2O	M.E.SYSTEM D.P.RANGE IN.H2O	RUN NO.
TFG-2A	LS	Y	Y	N/A	30000	12.5	1200	49.8	15.0	50-55	6.6	0.44-0.50	TFG-2A
TFG-2B	LS	Y	N	N/A	30000	12.5	1200	49.8	15.0	30-39	9.2	0.56-0.60	TFG-2B
TFG-2C	LS	Y	N	N/A	30000	12.5	1200	49.8	15.0	32-42	8.6	0.49-0.60	TFG-2C
TFG-2D	LS	Y	N	N/A	20000	8.4	12	0.7	15.0	35-42	4.8	0.17-0.24	TFG-2D
TFG-2E	LS	Y	N	N/A	30000	12.5	600	24.9	15.0	37-43	4.9	0.49-0.56	TFG-2E
TFG-2F	LS	Y	N	N/A	30000	12.5	1200	49.8	15.0	34-42	6.8	0.43-0.49	TFG-2F
525-2A	LS	Y	N	N/A	25000	10.4	1200	59.8	15.0	31-42	6.0	N/A	525-2A
526-2A	LS	Y	N	N/A	20500	8.6	1200	72.9	15.0	35-47	4.5	0.15-0.26	526-2A
527-2A	LS	Y	N	N/A	20500	8.6	1200	72.9	15.0	34-39	4.7	0.30-1.00	527-2A
528-2A	LS	Y	N	N/A	20500	8.6	1200	72.9	15.0	25-33	5.1	0.16-0.20	528-2A
529-2A	LS	Y	N	N/A	20500	8.6	1200	72.9	15.0	30-47	5.1	0.19-0.23	529-2A
530-2A	LS	Y	N	N/A	20500	8.6	1200	72.9	15.0	30-43	4.9	0.17-0.25	530-2A
531-2A	LS	Y	Y	N/A	20500	8.6	1200	72.9	8.0	35-42	5.4	0.19-0.35	531-2A
532-2A	LS	Y	Y	5.80	20500	8.6	1700	103.3	8.0	32-43	4.6	0.15-0.19	532-2A
533-2A	LS	Y	Y	5.80	20500	8.6	1200	72.9	15.0	29-38	4.7	0.17-0.25	533-2A
534-2A	LS	Y	N	5.80	20500	8.6	1200	72.9	15.0	30-40	4.3	0.15-0.20	534-2A
535-2A	LS	Y	N	N/A	20500	8.6	1200	72.9	15.0	34-42	4.3	0.10-0.20	535-2A
535-2B	LS	Y	N	N/A	20500	8.6	1200	72.9	15.0	34-42	4.4	0.15-0.20	535-2B
536-2A	LS	Y	N	N/A	24000	10.0	1200	62.3	15.0	32-43	5.4	0.30-0.40	536-2A
537-2A	LS	Y	N	N/A	24000	10.0	1400	72.7	15.0	33-40	6.1	0.40-0.55	537-2A
538-2A	LS	Y	N	N/A	24000	10.0	1400	72.7	15.0	31-40	6.3	0.15-0.25	538-2A
539-2A	LS	Y	N	N/A	28800	12.0	1000	43.3	15.0	40	6.8	0.33-0.50	539-2A
540-2A	LS	Y	N	N/A	28800	12.0	1000	43.3	15.0	40	6.4	0.50-0.53	540-2A
541-2A	LS	Y	N	N/A	28800	12.0	1000	43.3	15.0	40	6.5	0.50-0.65	541-2A
542-2A	LS	Y	N	5.40	28800	12.0	1000	43.3	15.0	40	6.9	0.48-0.50	542-2A
543-2A	LS	Y	N	5.40	28800	12.0	1000	43.3	15.0	40	6.7	0.50-0.53	543-2A
544-2A	LS	Y	N	N/A	20500	8.6	1200	72.9	13.0	35-40	5.3	0.15-0.20	544-2A
545-2A	LS	Y	N	5.40	28800	12.0	1000	43.3	15.0	35-40	5.3	0.40-0.45	545-2A
546-2A	LS	Y	N	5.40	30000	12.5	1000	41.5	15.0	35-44	8.6	0.65-0.80	546-2A
547-2A	LS	Y	N	5.50	30000	12.5	1000	41.5	15.0	35-43	7.4	0.65-1.10	547-2A
548-2A	LS	Y	N	5.50	30000	12.5	1000	41.5	15.0	22	7.0	0.58-0.65	548-2A
549-2A	LS	Y	N	5.50	30000	12.5	1000	41.5	15.0	30	6.4	0.58-0.65	549-2A
550-2A	LS	Y	N	5.50	30000	12.5	1000	41.5	15.0	37-41	6.4	0.66-0.83	550-2A
551-2A	LS	Y	N	5.50	30000	12.5	1000	41.5	15.0	39-41	6.6	0.66-0.80	551-2A
552-2A	LS	Y	N	5.50	30000	12.5	1200	49.8	15.0	38-41	7.7	0.68-0.75	552-2A
553-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	15.0	32-37	8.6	0.31-0.36	553-2A
554-2A	LS	Y	N	N/A	22500	9.4	1200	66.5	15.0	36-40	5.2	0.18-0.40	554-2A
555-2A	LS	Y	N	N/A	22500	9.4	1200	66.5	15.0	25	5.2	0.18-0.23	555-2A
556-2A	LS	Y	N	N/A	22500	9.4	1200	66.5	15.0	31-45	5.0	0.16-0.23	556-2A
557-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	15.0	39-44	7.4	0.36-0.44	557-2A
558-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	15.0	34-42	7.5	0.37-0.43	558-2A
559-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	15.0	36-42	7.6	0.38-0.43	559-2A
560-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	15.0	36-41	7.6	0.38-0.42	560-2A
561-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	15.0	37-44	7.4	0.35-0.40	561-2A

TCA OPERATING CONDITIONS (CONTINUED)

RUN NO.	EFFLU RES TIME MIN	TCA LOW PH TANK RES TIME MIN.	OXID AIR RATE SCFM	EDUCTOR CIRCUL RATE GPM	BLEED TO OX TANK GPM	BLEED OXID TANK PH	H2SO4 RATE GPM	RUN NO.
TFG-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	TFG-2A
TFG-2B	12.0	N/A	N/A	N/A	N/A	N/A	N/A	TFG-2B
TFG-2C	12.0	N/A	N/A	N/A	N/A	N/A	N/A	TFG-2C
TFG-2D	12.0	N/A	N/A	N/A	N/A	N/A	N/A	TFG-2D
TFG-2E	24.0	N/A	N/A	N/A	N/A	N/A	N/A	TFG-2E
TFG-2F	12.0	N/A	N/A	N/A	N/A	N/A	N/A	TFG-2F
525-2A	10.0	N/A	N/A	N/A	N/A	N/A	N/A	525-2A
526-2A	10.0	N/A	N/A	N/A	N/A	N/A	N/A	526-2A
527-2A	10.0	N/A	N/A	N/A	N/A	N/A	N/A	527-2A
528-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	528-2A
529-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	529-2A
530-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	530-2A
531-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	531-2A
532-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	532-2A
533-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	533-2A
534-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	534-2A
535-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	535-2A
535-2B	15.0	N/A	N/A	N/A	N/A	N/A	N/A	535-2B
536-2A	20.0	N/A	N/A	N/A	N/A	N/A	N/A	536-2A
537-2A	20.0	N/A	N/A	N/A	N/A	N/A	N/A	537-2A
538-2A	20.0	N/A	N/A	N/A	N/A	N/A	N/A	538-2A
539-2A	25.0	N/A	N/A	N/A	N/A	N/A	N/A	539-2A
540-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	540-2A
541-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	541-2A
542-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	542-2A
543-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	543-2A
544-2A	17.0	N/A	N/A	N/A	N/A	N/A	N/A	544-2A
545-2A	25.0	N/A	N/A	N/A	N/A	N/A	N/A	545-2A
546-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	546-2A
547-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	547-2A
548-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	548-2A
549-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	549-2A
550-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	550-2A
551-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	551-2A
552-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	552-2A
553-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	553-2A
554-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	554-2A
555-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	555-2A
556-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	556-2A
557-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	557-2A
558-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	558-2A
559-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	559-2A
560-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	560-2A
561-2A	15.0	N/A	N/A	N/A	N/A	N/A	N/A	561-2A

TCA OPERATING CONDITIONS

RUN NO.	ALK TYPE	FLY ASH	MGO	PH CONTR POINT	GAS RATE ACFM	GAS VEL FPS	TCA LIQ RATE GPM	TCA L/G GAL/ MACF	SOLID RECIRC NOM %	SOLIDS DISCH RANGE %	TCA D.P. IN. H2O	M.E.SYSTEM D.P.RANGE IN.H2O	RUN NO.
562-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	15.0	37-43	7.6	0.35-0.43	562-2A
562-2B	LS	Y	N	5.90	30000	12.5	1200	49.8	15.0	34-46	8.3	0.35-0.43	562-2B
563-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	15.0	36-46	8.0	0.40-0.43	563-2A
564-2A	LS	Y	N	5.20	30000	12.5	1200	49.8	15.0	38-45	7.9	0.38-0.45	564-2A
565-2A	LS	Y	N	5.20	30000	12.5	1000	41.5	15.0	34-43	7.7	0.30-0.35	565-2A
566-2A	LS	Y	N	5.90	30000	12.5	1000	41.5	15.0	34-44	9.4	0.30-0.40	566-2A
567-2A	LS	Y	N	N/A	30000	12.5	1000	41.5	15.0	37-43	9.2	0.35-0.38	567-2A
568-2A	LS	Y	N	5.50	30000	12.5	1000	41.5	15.0	38-46	9.3	0.33-0.40	568-2A
569-2A	LS	Y	N	5.50	30000	12.5	1000	41.5	15.0	33-44	8.4	0.25-0.35	569-2A
569-2B	LS	Y	N	5.50	30000	12.5	1000	41.5	15.0	37-44	7.9	0.30-0.35	569-2B
570-2A	LS	Y	N	N/A	30000	12.5	1000	41.5	15.0	34-41	7.5	0.30-0.35	570-2A
571-2A	LS	Y	N	N/A	30000	12.5	1000	41.5	15.0	34-42	7.0	0.33-0.35	571-2A
571-2B	LS	Y	N	N/A	30000	12.5	1000	41.5	15.0	-	N/A	-	571-2B
572-2A	LS	Y	N	5.20	30000	12.5	1000	41.5	15.0	34-47	6.7	0.30-0.40	572-2A
573-2A	LS	Y	N	5.50	30000	12.5	1000	41.5	15.0	34-43	6.9	0.30-0.35	573-2A
575-2A	LS	Y	N	5.50	30000	12.5	1000	41.5	15.0	35-39	6.6	0.30-0.38	575-2A
576-2A	LS	Y	N	5.70	30000	12.5	1000	41.5	15.0	37-42	7.5	0.35-0.40	576-2A
576-2B	LS	Y	N	N/A	30000	12.5	1000	41.5	15.0	-	N/A	-	576-2B
577-2A	LS	Y	N	N/A	30000	12.5	1000	41.5	15.0	39-43	8.8	0.35-0.41	577-2A
578-2A	LS	Y	N	N/A	30000	12.5	1000	41.5	15.0	-	N/A	-	578-2A
579-2A	LS	Y	N	5.20	30000	12.5	1000	41.5	15.0	40-45	9.7	0.45-0.55	579-2A
580-2A	LS	Y	N	N/A	30000	12.5	1000	41.5	15.0	-	N/A	-	580-2A
581-2A	LS	Y	N	N/A	28000	11.7	1200	53.4	15.0	35-42	N/A	0.28-0.35	581-2A
582-2A	LS	Y	N	N/A	28000	11.7	1200	53.4	15.0	N/A	N/A	N/A	582-2A
583-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	15.0	33-41	9.5	0.45-0.53	583-2A
583-2B	LS	Y	Y	N/A	30000	12.5	1200	49.8	15.0	55-64	10.0	0.45-0.53	583-2B
584-2A	LS	Y	Y	N/A	30000	12.5	1200	49.8	15.0	32-61	9.0	0.45-0.55	584-2A
585-2A	LS	Y	Y	N/A	30000	12.5	900	37.4	15.0	33-36	7.8	0.53-0.58	585-2A
586-2A	LS	Y	Y	N/A	30000	12.5	1200	49.8	15.0	36-37	3.5	0.52-0.60	586-2A
587-2A	LS	Y	Y	N/A	30000	12.5	1200	49.8	8.0	30-55	10.3	0.45-0.52	587-2A
588-2A	LS	Y	Y	N/A	20500	8.6	1200	72.9	15.0	60-68	5.4	0.18-0.25	588-2A
589-2A	LS	Y	Y	5.40	30000	12.5	1200	49.8	15.0	52-61	8.8	0.45-0.52	589-2A
590-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	13.8	62-70	11.4	0.40-0.48	590-2A
590-2B	LS	Y	N	N/A	30000	12.5	1200	49.8	14.7	56-60	10.5	0.42-0.52	590-2B
591-2A	LS	Y	Y	N/A	30000	12.5	1200	49.8	14.4	54-60	10.6	0.45-0.60	591-2A
592-2A	LS	Y	Y	N/A	30000	12.5	1200	49.8	15.0	51-59	8.9	0.52-0.60	592-2A
593-2A	LS	Y	Y	N/A	30000	12.5	900	37.4	14.8	52-62	7.2	0.49-0.66	593-2A
594-2A	LS	Y	Y	N/A	30000	12.5	1200	49.8	15.1	53-54	8.0	0.51-0.56	594-2A
601-2A	L	Y	Y	7.00	30000	12.5	1200	49.8	8.0	54-60	8.7	0.47-0.52	601-2A
602-2A	L	Y	Y	7.00	30000	12.5	1200	49.8	15.0	57-60	8.3	0.49-0.51	602-2A
603-2A	L	Y	Y	7.00	30000	12.5	1200	49.8	8.0	58-63	8.3	0.49-0.53	603-2A
604-2A	L	Y	Y	7.00	30000	12.5	900	37.4	8.0	58-62	7.3	0.52-0.88	604-2A
605-2A	L	Y	Y	7.00	20500	8.6	1200	72.9	8.0	51-59	4.8	0.25-0.32	605-2A
606-2A	L	Y	Y	8.00	30000	12.5	900	37.4	8.0	57-62	6.7	0.51-0.56	606-2A

TCA OPERATING CONDITIONS (CONTINUED)

RUN NO.	EFFLU RES TIME MIN	TCA LOW PH TANK RES TIME MIN.	OXID AIR RATE SCFM	EDUCTOR CIRCUL RATE GPM	BLEED TO OX TANK GPM	BLEED OXID TANK PH	H2SO4 RATE GPM	RUN NO.
562-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	562-2A
562-2B	12.0	N/A	N/A	N/A	N/A	N/A	N/A	562-2B
563-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	563-2A
564-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	564-2A
565-2A	14.4	N/A	N/A	N/A	N/A	N/A	N/A	565-2A
566-2A	14.4	N/A	N/A	N/A	N/A	N/A	N/A	566-2A
567-2A	14.4	N/A	N/A	N/A	N/A	N/A	N/A	567-2A
568-2A	14.4	N/A	N/A	N/A	N/A	N/A	N/A	568-2A
569-2A	10.8	N/A	N/A	N/A	N/A	N/A	N/A	569-2A
569-2B	10.8	N/A	N/A	N/A	N/A	N/A	N/A	569-2B
570-2A	10.8	N/A	N/A	N/A	N/A	N/A	N/A	570-2A
571-2A	10.8	N/A	N/A	N/A	N/A	N/A	N/A	571-2A
571-2B	10.8	N/A	N/A	N/A	N/A	N/A	N/A	571-2B
572-2A	10.8	N/A	N/A	N/A	N/A	N/A	N/A	572-2A
573-2A	14.4	N/A	N/A	N/A	N/A	N/A	N/A	573-2A
575-2A	14.4	N/A	N/A	N/A	N/A	N/A	N/A	575-2A
576-2A	14.4	N/A	N/A	N/A	N/A	N/A	N/A	576-2A
576-2B	14.4	N/A	N/A	N/A	N/A	N/A	N/A	576-2B
577-2A	14.4	N/A	N/A	N/A	N/A	N/A	N/A	577-2A
578-2A	14.4	N/A	N/A	N/A	N/A	N/A	N/A	578-2A
579-2A	10.8	N/A	N/A	N/A	N/A	N/A	N/A	579-2A
580-2A	10.8	N/A	N/A	N/A	N/A	N/A	N/A	580-2A
581-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	581-2A
582-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	582-2A
583-2A	3.0	N/A	N/A	N/A	N/A	N/A	N/A	583-2A
583-2B	3.0	N/A	N/A	N/A	N/A	N/A	N/A	583-2B
584-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	584-2A
585-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	585-2A
586-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	586-2A
587-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	587-2A
588-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	588-2A
589-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	589-2A
590-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	590-2A
590-2B	4.1	N/A	N/A	N/A	N/A	N/A	N/A	590-2B
591-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	591-2A
592-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	592-2A
593-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	593-2A
594-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	594-2A
601-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	601-2A
602-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	602-2A
603-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	603-2A
604-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	604-2A
605-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	605-2A
606-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	606-2A

TCA OPERATING CONDITIONS

RUN NO.	ALK TYPE	FLY ASH	MGO	PH CONTR POINT	GAS RATE ACFM	GAS VEL FPS	TCA LIQ RATE GPM	TCA L/G GAL/ MACF	SOLID RECIRC NOM %	SOLIDS DISCH RANGE %	TCA D.P. IN. H2O	M.E.SYSTEM D.P.RANGE IN.H2O	RUN NO.
607-2A	L	Y	Y	8.00	30000	12.5	900	37.4	8.0	53-59	6.4	0.45-0.47	607-2A
608-2A	L	Y	Y	8.00	30000	12.5	900	37.4	15.0	55-60	7.2	0.49-0.54	608-2A
608-2B	L	Y	Y	8.00	30000	12.5	900	37.4	15.0	52-56	6.3	0.48-0.53	608-2B
609-2A	L	Y	Y	7.00	30000	12.5	900	37.4	8.0	55-63	6.0	0.48-0.53	609-2A
610-2A	L	Y	Y	8.00	30000	12.5	900	37.4	8.0	53-67	5.8	0.47-0.53	610-2A
611-2A	L	Y	Y	8.00	30000	12.5	900	37.4	8.0	55-65	6.6	0.48-0.53	611-2A
612-2A	L	Y	Y	8.00	30000	12.5	900	37.4	8.0	57-61	7.2	0.53-0.57	612-2A
613-2A	L	Y	Y	7.00	30000	12.5	1200	49.8	8.0	58-61	7.7	0.57-0.61	613-2A
614-2A	L	Y	Y	8.00	30000	12.5	900	37.4	8.0	55-61	6.0	0.45-0.60	614-2A
615-2A	L	Y	Y	7.00	30000	12.5	1200	49.8	8.0	59-67	7.8	0.46-0.56	615-2A
616-2A	L	Y	N	8.00	30000	12.5	1200	49.8	8.0	50-63	7.4	0.42-0.51	616-2A
617-2A	L	Y	N	8.00	30000	12.5	1200	49.8	15.0	54-60	8.6	0.42-0.49	617-2A
618-2A	L	Y	N	7.00	30000	12.5	1200	49.8	7.8	60-65	11.0	0.40-0.52	618-2A
618-2B	L	Y	N	7.00	30000	12.5	1200	49.8	7.5	55-63	13.3	0.46-0.58	618-2B
619-2A	L	Y	Y	7.00	30000	12.5	1200	49.8	8.0	49-62	9.4	0.28-0.56	619-2A
620-2A	L	Y	Y	7.00	30000	12.5	900	37.4	8.1	52-60	8.2	0.46-0.62	620-2A
621-2A	L	Y	Y	7.00	30000	12.5	1200	49.8	8.1	48-62	10.8	0.[illegible]0-0.64	621-2A
622-2A	L	Y	Y	7.00	30000	12.5	900	37.4	8.6	37-58	6.6	0.50-0.59	622-2A
622-2B	L	Y	Y	7.00	30000	12.5	900	37.4	8.0	37-61	6.7	0.51-0.60	622-2B
623-2A	L	Y	Y	7.00	30000	12.5	1200	49.8	8.2	53-65	7.0	0.54-0.68	623-2A
624-2A	L	Y	Y	7.00	30000	12.5	900	37.4	8.0	35-49	6.5	0.63-0.78	624-2A
625-2A	L	Y	N	8.00	N/A	N/A	1450	N/A	8.1	28-63	N/A	0.11-0.57	625-2A
701-2A	LS	N	N	N/A	30000	12.5	1200	49.8	8.0	31-43	8.4	0.42-0.56	701-2A
702-2A	LS	N	N	N/A	30000	12.5	1200	49.8	15.0	33-42	7.7	0.45-0.50	702-2A
703-2A	LS	N	N	N/A	30000	12.5	1200	49.8	8.0	41-55	7.4	0.43-0.49	703-2A
704-2A	LS	N	N	N/A	30000	12.5	1200	49.8	8.0	40-46	8.0	0.40-0.54	704-2A
705-2A	LS	N	N	N/A	30000	12.5	1200	49.8	15.0	N/A	8.0	0.43-0.52	705-2A
706-2A	LS	N	N	N/A	30000	12.5	1200	49.8	15.0	N/A	N/A	0.44-0.59	706-2A
707-2A	SL	N	N	N/A	30000	12.5	1200	49.8	15.0	38-42	6.6	0.45-0.57	707-2A
708-2A	LS	N	N	N/A	30000	12.5	1200	49.8	15.0	37-43	7.0	0.44-0.49	708-2A
709-2A	LS	N	N	N/A	30000	12.5	1200	49.8	15.0	37-41	6.4	0.44-0.49	709-2A
710-2A	LS	N	N	N/A	30000	12.5	1200	49.8	15.0	38-48	6.4	0.47-0.55	710-2A
711-2A	LS	N	N	N/A	30000	12.5	1200	49.8	15.0	35-40	6.6	0.50-0.62	711-2A
712-2A	LS	N	N	N/A	30000	12.5	1200	49.8	15.0	36-43	6.7	0.48-0.61	712-2A
713-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	14.9	38-42	8.2	0.44-0.50	713-2A
714-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	15.2	32-40	8.4	0.33-0.46	714-2A
714-2B	LS	Y	N	N/A	N/A	N/A	1200	N/A	N/A	N/A	N/A	N/A	714-2B
715-2A	LS	Y	N	5.80	30000	12.5	1000	41.5	15.0	30-42	11.2	0.44-0.55	715-2A
716-2A	LS	Y	N	5.75	27000	11.3	1000	46.1	14.4	33-41	14.4	0.34-0.44	716-2A
717-2A	LS	Y	N	N/A	N/A	N/A	1000	N/A	14.7	31-45	9.6	0.17-0.52	717-2A
718-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	14.4	36-40	7.4	0.40-0.50	718-2A
719-2A	LS	Y	N	N/A	18000	7.5	1200	83.1	14.8	35-41	3.3	0.13-0.20	719-2A
801-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	14.6	34-45	7.1	0.47-0.51	801-2A
801-2B	LS	Y	N	N/A	30000	12.5	1200	49.8	14.6	34-45	7.1	0.47-0.51	801-2B

TCA OPERATING CONDITIONS (CONTINUED)

RUN NO.	EFFLU RES TIME MIN	TCA LOW PH TANK RES TIME MIN.	OXID AIR RATE SCFM	EDUCTOR CIRCUL RATE GPM	BLEED TO OX TANK GPM	BLEED OXID TANK PH	H2SO4 RATE GPM	RUN NO.
607-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	607-2A
608-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	608-2A
608-2B	5.4	N/A	N/A	N/A	N/A	N/A	N/A	608-2B
609-2A	5.4	N/A	N/A	N/A	N/A	N/A	N/A	609-2A
610-2A	5.4	N/A	N/A	N/A	N/A	N/A	N/A	610-2A
611-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	611-2A
612-2A	3.0	N/A	N/A	N/A	N/A	N/A	N/A	612-2A
613-2A	3.0	N/A	N/A	N/A	N/A	N/A	N/A	613-2A
614-2A	16.0	N/A	N/A	N/A	N/A	N/A	N/A	614-2A
615-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	615-2A
616-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	616-2A
617-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	617-2A
618-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	618-2A
618-2B	4.1	N/A	N/A	N/A	N/A	N/A	N/A	618-2B
619-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	619-2A
620-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	620-2A
621-2A	3.0	N/A	N/A	N/A	N/A	N/A	N/A	621-2A
622-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	622-2A
622-2B	4.1	N/A	N/A	N/A	N/A	N/A	N/A	622-2B
623-2A	3.0	N/A	N/A	N/A	N/A	N/A	N/A	623-2A
624-2A	3.0	N/A	N/A	N/A	N/A	N/A	N/A	624-2A
625-2A	3.4	N/A	N/A	N/A	N/A	N/A	N/A	625-2A
701-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	701-2A
702-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	702-2A
703-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	703-2A
704-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	704-2A
705-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	705-2A
706-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	706-2A
707-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	707-2A
708-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	708-2A
709-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	709-2A
710-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	710-2A
711-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	711-2A
712-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	712-2A
713-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	713-2A
714-2A	4.1	N/A	N/A	N/A	N/A	N/A	N/A	714-2A
714-2B	4.1	N/A	N/A	N/A	N/A	N/A	N/A	714-2B
715-2A	14.4	N/A	N/A	N/A	N/A	N/A	N/A	715-2A
716-2A	14.4	N/A	N/A	N/A	N/A	N/A	N/A	716-2A
717-2A	14.4	N/A	N/A	N/A	N/A	N/A	N/A	717-2A
718-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	718-2A
719-2A	12.0	N/A	N/A	N/A	N/A	N/A	N/A	719-2A
801-2A	12.0	N/A	600	1590	N/A	N/A	N/A	801-2A
801-2B	15.4	N/A	530	1590	N/A	N/A	N/A	801-2B

TCA OPERATING CONDITIONS

RUN NO.	ALK TYPE	FLY ASH	MGO	PH CONTR POINT	GAS RATE ACFM	GAS VEL FPS	TCA LIQ RATE GPM	TCA L/G GAL/ MACF	SOLID RECIRC NOM %	SOLIDS DISCH RANGE %	TCA D.P. IN. H2O	M.E.SYSTEM D.P.RANGE IN.H2O	RUN NO.
802-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	15.3	32-38	8.4	0.47-0.56	802-2A
803-2A	LS	Y	N	5.00	30000	12.5	1200	49.8	14.9	33-48	8.4	0.40-0.52	803-2A
804-2A	LS	Y	N	5.00	30000	12.5	1200	49.8	15.0	30-50	8.3	0.40-0.46	804-2A
805-2A	LS	Y	N	5.30	30000	12.5	1200	49.8	15.0	26-39	8.2	0.37-0.46	805-2A
806-2A	LS	Y	N	5.30	30000	12.5	1200	49.8	14.4	32-44	8.2	0.31-0.40	806-2A
807-2A	LS	Y	N	5.40	30000	12.5	1200	49.8	14.9	28-44	8.5	0.34-0.44	807-2A
808-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	14.8	24-64	8.2	0.44-0.50	808-2A
809-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	14.1	80-89	8.4	0.35-0.43	809-2A
810-2A	LS	Y	N	5.40	30000	12.5	1200	49.8	15.0	84-91	8.6	0.35-0.45	810-2A
811-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	14.6	35-50	8.1	0.30-0.47	811-2A
812-2A	LS	Y	N	N/A	30000	12.5	1200	49.8	15.0	32-44	8.0	0.30-0.50	812-2A
813-2A	LS	Y	N	5.30	30000	12.5	1200	49.8	15.0	35-44	9.6	0.47-0.58	813-2A
814-2A	LS	Y	N	5.30	30000	12.5	1200	49.8	14.6	33-42	9.6	0.47-0.55	814-2A
815-2A	LS	Y	N	N/A	30000	12.5	1000	41.5	14.9	35-41	11.9	0.44-0.54	815-2A
816-2A	LS	Y	N	N/A	30000	12.5	1000	41.5	15.2	38-42	13.0	0.40-0.48	816-2A
817-2A	LS	Y	N	N/A	20000	8.4	1000	62.3	14.4	31-48	6.8	0.15-0.26	817-2A
818-2A	LS	Y	N	N/A	25000	10.4	1000	49.8	14.8	38-42	8.5	0.26-0.36	818-2A
818-2B	LS	Y	N	N/A	25000	10.4	1000	49.8	14.3	35-42	8.2	0.24-0.35	818-2B
819-2A	LS	Y	N	N/A	20000	8.4	1000	62.3	12.9	32-42	7.4	0.11-0.26	819-2A
820-2A	LS	Y	N	5.90	20000	8.4	1000	62.3	13.8	32-42	6.9	0.11-0.21	820-2A
821-2A	LS	Y	Y	N/A	30000	12.5	1200	49.8	14.9	78-80	7.8	0.54-0.62	821-2A

TCA OPERATING CONDITIONS (CONTINUED)

RUN NO.	EFFLU RES TIME MIN	TCA LOW PH TANK RES TIME MIN.	OXID AIR RATE SCFM	EDUCTOR CIRCUL RATE GPM	BLEED TO OX TANK GPM	BLEED OXID TANK PH	H2SO4 RATE GPM	RUN NO.
802-2A	23.5	N/A	485	1600	N/A	N/A	N/A	802-2A
803-2A	23.5	N/A	465	1600	N/A	N/A	N/A	803-2A
804-2A	23.5	N/A	410	1600	N/A	N/A	N/A	804-2A
805-2A	23.5	N/A	470	1600	N/A	N/A	N/A	805-2A
806-2A	23.5	N/A	290	1200	N/A	N/A	N/A	806-2A
807-2A	23.5	2.9	475	1600	N/A	N/A	N/A	807-2A
808-2A	23.5	2.9	200	1600	N/A	N/A	N/A	808-2A
809-2A	15.7	1.9	300	1600	N/A	N/A	N/A	809-2A
810-2A	15.7	1.9	300	1600	N/A	N/A	N/A	810-2A
811-2A	23.5	2.9	270	1600	N/A	N/A	N/A	811-2A
812-2A	15.7	1.9	350	1600	N/A	N/A	N/A	812-2A
813-2A	23.5	N/A	310	1600	N/A	N/A	N/A	813-2A
814-2A	15.7	N/A	145	1200	N/A	N/A	N/A	814-2A
815-2A	14.4	N/A	N/A	N/A	N/A	N/A	N/A	815-2A
816-2A	14.4	N/A	N/A	N/A	N/A	N/A	N/A	816-2A
817-2A	14.4	N/A	N/A	N/A	N/A	N/A	N/A	817-2A
818-2A	14.4	N/A	N/A	N/A	N/A	N/A	N/A	818-2A
818-2B	14.4	N/A	N/A	N/A	N/A	N/A	N/A	818-2B
819-2A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	819-2A
820-2A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	820-2A
821-2A	4.1	4.1	170	N/A	N/A	5.35	N/A	821-2A

TCA ANALYTICAL RUN SUMMARY (GASES)

RUN NO.	AVG SO2 IN PPM	MIN SO2 IN PPM	MAX SO2 IN PPM	AVG SO2 OUT PPM	MIN SO2 OUT PPM	MAX SO2 OUT PPM	AVG SO2 REM %	MIN SO2 REM %	MAX SO2 REM %	AVG MAKE PER PASS MMOL /L	MIN MAKE PER PASS MMOL /L	MAX MAKE PER PASS MMOL /L	AVG O2 IN %	MIN O2 IN %	MAX O2 IN %	AVG NO2 IN PPM	MIN NO2 IN PPM	MAX NO2 IN PPM	AVG BOIL LOAD MEGA WATT	MIN BOIL LOAD MEGA WATT	MAX BOIL LOAD MEGA WATT
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TFG-2A	3084	2640	3440	312	70	1340	89	56	97	14.5	10.1	16.3	9.1	7.9	10.2	N/A	N/A	N/A	145	124	150
TFG-2B	3274	2560	3600	409	120	700	86	76	95	15.0	12.9	16.9	8.1	5.8	9.5	N/A	N/A	N/A	126	93	150
TFG-2C	3260	2760	4080	570	360	1040	80	72	86	13.9	12.1	16.2	8.2	6.3	9.2	N/A	N/A	N/A	141	102	149
TFG-2D	3778	3160	4340	767	580	900	77	75	80	****	****	****	7.8	6.7	9.2	N/A	N/A	N/A	138	92	153
TFG-2E	3296	1180	4300	1525	1240	1940	41	-81	55	17.0	-10.3	22.8	7.4	4.5	8.5	N/A	N/A	N/A	147	125	151
TFG-2F	3000	2520	3840	724	500	1080	73	68	78	11.6	10.2	14.0	7.2	5.7	9.2	N/A	N/A	N/A	142	100	160
525-2A	2852	2520	3200	234	40	460	90	84	98	13.7	11.9	15.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
526-2A	3134	2800	3880	341	120	440	87	84	96	14.6	12.7	18.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
527-2A	3179	2060	4800	452	140	1200	85	72	94	14.2	9.7	18.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
528-2A	3432	2800	4420	873	540	1400	72	65	79	17.4	15.6	20.3	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
529-2A	3575	3000	4000	688	440	1000	78	72	84	10.2	9.1	11.4	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
530-2A	3350	2480	4000	781	360	1140	74	68	84	17.5	14.7	20.1	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
531-2A	3284	2400	3880	461	110	760	84	78	96	19.6	14.4	22.5	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
532-2A	3742	3480	4040	632	340	860	81	76	90	21.5	20.5	23.2	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
533-2A	3225	2280	3920	133	30	320	95	89	99	21.7	14.4	26.9	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
534-2A	2616	1200	3360	462	60	720	81	76	94	7.6	4.1	9.3	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
535-2A	3206	1360	4700	539	100	1210	81	70	92	9.4	4.5	13.2	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
535-2B	3013	1480	4840	554	125	1300	80	66	91	8.7	4.8	12.7	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
536-2A	3069	1240	4320	577	80	1150	80	68	93	10.3	4.8	14.0	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
537-2A	2780	2200	3680	335	170	500	86	82	92	8.7	7.0	11.4	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
538-2A	3152	1960	4030	340	120	610	88	82	94	10.1	6.6	12.2	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
539-2A	3234	1920	4060	412	100	900	86	73	97	17.0	10.8	21.5	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
540-2A	3235	2520	3850	449	170	950	84	73	93	16.7	14.2	18.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
541-2A	3690	3520	3840	630	560	700	81	79	82	18.3	17.7	19.0	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
542-2A	3494	3080	4000	661	450	920	79	74	84	16.9	15.3	18.2	N/A	N/A	N/A	0	N/A	N/A	35	35	35
543-2A	2906	2440	3440	495	340	675	81	78	85	14.4	12.6	16.4	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
544-2A	3246	2480	3860	458	230	670	84	74	90	9.9	6.6	11.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
545-2A	3155	2440	3640	605	200	910	79	72	92	15.2	11.7	16.8	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
546-2A	2948	1380	3680	578	220	1250	78	62	90	14.7	9.2	18.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
547-2A	3128	2400	3680	534	300	680	81	76	86	16.1	12.7	19.2	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
548-2A	2611	2240	2960	451	300	680	80	74	87	13.4	11.3	15.4	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
549-2A	2610	2080	3160	583	400	780	75	73	79	12.5	10.4	15.0	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
550-2A	2630	2080	3240	574	400	840	76	71	81	12.7	10.1	15.2	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
551-2A	3080	3040	3120	673	640	700	75	75	77	14.8	14.8	14.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
552-2A	3035	2640	3400	445	360	560	83	81	86	13.5	11.6	15.0	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
553-2A	2426	2080	2680	446	280	620	80	73	85	10.2	9.4	11.6	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
554-2A	2822	1880	3120	551	260	760	78	73	85	8.8	6.3	9.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
555-2A	2430	2000	2880	500	290	720	77	72	84	7.5	6.7	8.3	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
556-2A	2296	1480	3840	442	160	940	80	72	89	7.2	5.1	11.1	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
557-2A	2695	1360	3800	624	180	1120	75	66	85	10.6	6.1	15.3	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
558-2A	2603	1040	3820	543	110	1040	78	68	88	10.6	4.9	14.8	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
559-2A	3226	1520	4020	701	180	1160	76	68	88	13.0	6.9	15.0	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
560-2A	3357	3000	4290	715	520	1190	76	69	82	13.6	12.3	15.7	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
561-2A	3043	1920	3800	675	280	1020	75	70	84	12.2	8.5	14.6	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A

TCA ANALYTICAL RUN SUMMARY (GASES)

RUN NO.	AVG SO2 IN PPM	MIN SO2 IN PPM	MAX SO2 IN PPM	AVG SO2 OUT PPM	MIN SO2 OUT PPM	MAX SO2 OUT PPM	AVG SO2 REM %	MIN SO2 REM %	MAX SO2 REM %	AVG MAKE PER PASS MMOL /L	MIN MAKE PER PASS MMOL /L	MAX MAKE PER PASS MMOL /L	AVG O2 IN %	MIN O2 IN %	MAX O2 IN %	AVG NO2 IN PPM	MIN NO2 IN PPM	MAX NO2 IN PPM	AVG BOIL LOAD MEGA WATT	MIN BOIL LOAD MEGA WATT	MAX BOIL LOAD MEGA WATT
562-2A	3085	2120	4060	523	200	1260	81	65	92	13.3	9.5	16.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
562-2B	3078	2440	3920	582	300	1020	79	71	86	12.9	10.9	15.7	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
563-2A	3216	2720	4000	435	240	890	85	73	91	14.5	12.4	17.3	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
564-2A	3238	2520	4040	1288	940	1670	55	46	68	9.6	7.0	13.5	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
565-2A	3627	2760	4320	1405	960	2000	57	49	66	13.1	10.6	16.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
566-2A	3108	2520	3920	532	240	1140	81	58	91	16.0	11.0	19.8	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
567-2A	3272	2280	4200	488	240	800	83	78	89	17.4	12.8	21.1	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
568-2A	3294	2720	3800	1089	480	1500	63	55	81	13.3	10.9	15.8	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
569-2A	3112	2240	4000	940	540	1500	67	56	74	13.1	10.4	15.8	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
569-2B	3066	2440	3840	1034	800	1500	62	57	68	12.2	9.7	15.4	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
570-2A	2958	2320	3840	775	500	1340	71	61	78	13.3	10.8	15.5	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
571-2A	2759	2120	3380	661	370	1040	73	66	81	12.9	10.9	14.7	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
571-2B	2574	2440	2800	744	480	1120	67	50	81	11.1	7.9	14.2	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
572-2A	3181	2440	3840	1254	920	1640	56	50	66	11.4	7.9	14.0	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
573-2A	2720	2720	2720	760	760	760	69	69	69	11.9	11.9	11.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
575-2A	2958	2600	3200	820	540	1040	69	63	77	13.0	11.3	14.3	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
576-2A	3247	2400	4000	813	500	1320	72	61	80	14.9	11.2	18.4	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
576-2B	3200	3040	3360	1110	1020	1200	61	56	66	12.6	10.9	14.2	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
577-2A	3205	2460	3920	553	340	860	81	74	87	16.5	13.2	19.6	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
578-2A	3063	2840	3160	538	220	1110	80	61	91	15.7	12.1	17.1	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
579-2A	3090	2760	3660	1130	840	1530	59	54	66	11.7	10.0	13.5	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
580-2A	3033	2660	3440	626	280	1000	78	68	88	14.8	14.8	14.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
581-2A	2814	2040	3660	421	120	860	83	74	94	11.6	9.3	13.5	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
582-2A	2900	2620	3040	381	90	1100	85	60	96	12.3	9.0	13.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
583-2A	3040	2200	3800	602	340	1000	78	66	85	12.6	9.3	15.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
583-2B	2954	2100	3600	370	60	900	86	68	97	13.5	9.8	16.1	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
584-2A	3016	2080	4000	171	40	400	93	84	98	15.0	10.2	19.1	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
585-2A	2948	2400	3880	399	180	700	85	79	93	17.7	14.9	21.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
586-2A	2877	2120	3960	538	280	1020	79	71	87	12.1	8.4	16.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
587-2A	3059	2400	3800	194	50	540	93	82	98	15.1	12.1	18.6	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
588-2A	2476	1780	3320	159	60	260	92	87	96	8.3	6.0	11.1	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
589-2A	3314	2200	4360	301	110	640	90	83	95	15.8	10.7	20.8	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
590-2A	2066	1960	2200	620	460	700	66	60	75	7.3	6.3	8.1	8.9	8.0	9.8	N/A	N/A	N/A	99	77	114
590-2B	2442	2000	2920	516	400	740	76	69	83	9.9	8.2	11.4	N/A	N/A	N/A	N/A	N/A	N/A	99	44	142
591-2A	2386	1240	3400	181	40	420	92	85	96	11.6	6.2	15.9	N/A	N/A	N/A	N/A	N/A	N/A	142	124	155
592-2A	2885	2280	3640	120	60	280	95	91	98	14.6	11.4	18.8	7.6	6.0	10.0	N/A	N/A	N/A	137	96	155
593-2A	2810	2400	3480	208	120	480	91	84	95	18.2	15.2	22.7	6.3	5.6	7.5	N/A	N/A	N/A	148	111	158
594-2A	2871	2080	3480	213	80	320	91	87	96	14.0	10.4	16.9	8.2	5.4	10.0	N/A	N/A	N/A	146	96	158
601-2A	2852	2520	3200	234	40	460	90	84	98	13.7	11.9	15.9	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
602-2A	3134	2800	3880	341	120	440	87	84	96	14.6	12.7	18.2	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
603-2A	3179	2060	4800	452	140	1200	85	72	94	14.2	9.7	18.4	N/A	N/A	N/A	0	N/A	N/A	N/A	N/A	N/A
604-2A	3432	2800	4420	873	540	1400	72	65	79	17.4	15.6	20.3	6.4	6.0	7.0	0	N/A	N/A	134	113	144
605-2A	3575	3000	4000	688	440	1000	78	72	84	10.2	9.1	11.4	6.0	5.2	6.8	0	N/A	N/A	143	128	148
606-2A	3350	2480	4000	781	360	1140	74	68	84	17.5	14.7	20.1	6.8	4.4	8.5	0	N/A	N/A	142	110	150

TCA ANALYTICAL RUN SUMMARY (GASES)

RUN NO.	AVG SO2 IN PPM	MIN SO2 IN PPM	MAX SO2 IN PPM	AVG SO2 OUT PPM	MIN SO2 OUT PPM	MAX SO2 OUT PPM	AVG SO2 REM %	MIN SO2 REM %	MAX SO2 REM %	AVG MAKE PER PASS MMOL /L	MIN MAKE PER PASS MMOL /L	MAX MAKE PER PASS MMOL /L	AVG O2 IN %	MIN O2 IN %	MAX O2 IN %	AVG NO2 IN PPM	MIN NO2 IN PPM	MAX NO2 IN PPM	AVG BOIL LOAD MEGA WATT	MIN BOIL LOAD MEGA WATT	MAX BOIL LOAD MEGA WATT
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607-2A	3295	2400	3880	440	110	760	85	78	96	19.8	14.4	24.6	6.1	4.5	9.8	0	N/A	N/A	142	103	148
608-2A	3742	3480	4040	632	340	860	81	76	90	21.5	20.5	23.2	5.9	5.0	7.6	0	N/A	N/A	131	54	145
608-2B	3225	2280	3920	133	30	320	95	89	99	21.7	14.4	26.9	6.6	4.7	9.0	0	N/A	N/A	131	100	150
609-2A	3130	2480	3860	619	120	920	77	69	96	17.3	13.1	23.7	7.0	5.0	11.2	0	N/A	N/A	141	112	163
610-2A	2987	2240	3720	426	180	660	84	78	93	17.8	13.0	21.1	7.2	4.9	9.5	0	N/A	N/A	140	115	148
611-2A	2912	2400	3520	510	340	740	80	76	85	16.6	14.3	19.1	6.3	5.2	8.0	0	N/A	N/A	133	100	148
612-2A	3092	2800	3760	539	440	700	80	77	83	17.6	15.9	21.1	6.3	5.0	8.1	0	N/A	N/A	146	141	150
613-2A	3280	2080	3920	511	180	780	83	78	90	14.4	10.0	16.2	8.2	6.1	10.3	0	N/A	N/A	143	136	147
614-2A	3556	3000	4240	758	240	1080	76	72	93	19.2	15.8	23.3	6.7	5.2	9.0	0	N/A	N/A	141	114	149
615-2A	3141	2500	3960	375	220	680	86	81	91	14.4	11.8	17.0	7.4	5.7	12.5	0	N/A	N/A	142	94	156
616-2A	3341	2680	4000	785	440	1260	73	63	86	13.1	9.7	16.8	6.4	5.0	10.5	0	N/A	N/A	146	80	156
617-2A	3107	2200	3600	586	260	780	79	75	87	13.0	10.1	15.0	6.6	4.5	9.1	0	N/A	N/A	146	101	157
618-2A	2138	1520	3040	251	120	520	87	81	92	9.9	7.4	13.2	N/A	N/A	N/A	N/A	N/A	N/A	83	20	154
618-2B	1763	1240	2840	69	20	180	96	93	98	9.0	6.5	14.0	7.9	6.0	10.0	N/A	N/A	N/A	69	52	123
619-2A	1813	320	3460	107	5	510	94	84	99	9.0	1.6	15.3	9.3	8.1	10.0	N/A	N/A	N/A	73	58	116
620-2A	1692	640	3660	166	20	740	91	78	97	10.7	4.4	20.1	8.0	5.1	9.8	N/A	N/A	N/A	113	70	146
621-2A	2035	560	3080	83	10	200	96	93	99	10.3	2.9	15.1	8.8	7.0	10.0	N/A	N/A	N/A	85	68	149
622-2A	2606	2360	3000	208	70	360	91	87	97	16.8	14.6	19.2	8.0	6.0	10.0	N/A	N/A	N/A	128	98	156
622-2B	2554	2240	2840	380	220	560	83	77	89	15.1	14.1	16.6	7.3	4.2	10.0	N/A	N/A	N/A	133	96	156
623-2A	2563	2080	2880	212	60	400	90	83	97	12.3	10.7	14.0	8.1	6.2	10.0	N/A	N/A	N/A	123	96	154
624-2A	2841	2060	3320	462	90	680	82	77	95	16.4	13.9	18.6	7.1	2.5	8.5	N/A	N/A	N/A	140	94	157
625-2A	2323	1320	3360	158	20	460	92	79	99	N/A	N/A	N/A	6.2	3.0	10.0	N/A	N/A	N/A	127	48	156
701-2A	2775	2000	3680	359	140	800	86	76	93	12.6	9.4	16.0	8.5	5.7	11.0	0	N/A	N/A	142	90	151
702-2A	2998	2200	3680	514	240	780	81	71	89	12.9	10.2	16.0	9.3	6.5	10.4	0	N/A	N/A	146	138	152
703-2A	3009	2560	3480	695	480	1080	74	66	82	11.9	10.5	14.6	8.4	7.5	9.7	0	N/A	N/A	141	105	150
704-2A	2778	1960	3520	555	320	1060	77	61	88	11.5	8.2	14.7	9.2	6.8	10.8	0	N/A	N/A	133	66	150
705-2A	2812	2400	3320	394	200	540	84	79	91	12.6	10.8	15.4	10.3	9.1	12.0	N/A	N/A	N/A	144	106	162
706-2A	2772	2200	3600	466	280	760	81	73	88	11.9	9.7	15.0	10.2	7.0	12.5	N/A	N/A	N/A	143	100	152
707-2A	3007	2720	3680	759	600	1140	72	66	77	11.5	10.1	12.8	8.4	6.0	11.4	N/A	N/A	N/A	141	112	152
708-2A	3092	2760	3760	1449	1080	2020	48	40	58	7.9	7.1	8.9	7.0	5.8	8.2	N/A	N/A	N/A	144	129	152
709-2A	3314	2800	3720	1362	920	1620	54	47	64	9.6	8.5	11.2	9.0	8.0	11.8	N/A	N/A	N/A	130	93	159
710-2A	3431	2520	3920	1436	860	1840	53	47	64	9.7	8.3	10.8	6.8	5.3	10.5	N/A	N/A	N/A	136	59	156
711-2A	3284	2840	3380	1114	800	1360	62	58	69	10.9	10.3	11.5	7.0	7.0	7.0	N/A	N/A	N/A	148	146	150
712-2A	3028	2400	3320	836	540	1050	69	64	76	11.1	9.0	12.3	6.5	5.7	8.4	N/A	N/A	N/A	138	50	150
713-2A	2678	2200	3040	452	320	700	81	74	87	11.5	9.8	13.5	7.9	6.4	10.4	N/A	N/A	N/A	137	100	152
714-2A	2675	2040	3960	321	120	860	87	76	94	12.3	10.0	16.5	7.6	6.0	11.5	N/A	N/A	N/A	136	95	154
714-2B	3130	2720	3460	320	180	440	89	86	93	N/A	N/A	N/A	6.3	6.0	6.6	N/A	N/A	N/A	150	148	152
715-2A	2978	2480	3580	404	260	600	84	81	89	16.1	13.2	18.5	8.6	7.4	9.4	N/A	N/A	N/A	138	99	154
716-2A	2684	2060	3200	213	110	330	91	88	95	14.0	11.1	16.2	7.5	5.8	9.2	N/A	N/A	N/A	136	105	153
717-2A	2660	1800	3740	362	100	650	86	81	95	N/A	N/A	N/A	7.0	5.5	9.9	N/A	N/A	N/A	141	82	156
718-2A	3234	2760	3520	703	620	860	75	72	78	13.0	11.0	14.2	7.8	4.8	10.0	N/A	N/A	N/A	141	103	152
719-2A	3061	2740	3400	390	320	480	85	83	88	8.4	7.6	9.3	7.6	3.0	10.0	N/A	N/A	N/A	146	115	154
801-2A	2782	1920	3520	744	260	1140	71	64	85	10.4	8.3	11.9	9.7	9.6	9.8	N/A	N/A	N/A	109	95	149
801-2B	2810	2600	2920	825	680	900	67	66	71	10.0	9.8	10.2	N/A	N/A	N/A	N/A	N/A	N/A	133	115	148

TCA ANALYTICAL RUN SUMMARY (GASES)

RUN NO.	AVG SO2 IN PPM	MIN SO2 IN PPM	MAX SO2 IN PPM	AVG SO2 OUT PPM	MIN SO2 OUT PPM	MAX SO2 OUT PPM	AVG SO2 REM %	MIN SO2 REM %	MAX SO2 REM %	AVG MAKE PER PASS MMOL /L	MIN MAKE PER PASS MMOL /L	MAX MAKE PER PASS MMOL /L	AVG O2 IN %	MIN O2 IN %	MAX O2 IN %	AVG NO2 IN PPM	MIN NO2 IN PPM	MAX NO2 IN PPM	AVG BOIL LOAD MEGA WATT	MIN BOIL LOAD MEGA WATT	MAX BOIL LOAD MEGA WATT
802-2A	2888	2520	3200	624	540	700	75	73	80	11.6	9.9	13.0	7.5	6.0	8.5	N/A	N/A	N/A	126	84	149
803-2A	2820	1760	3080	985	420	1500	61	46	74	9.2	6.9	10.8	8.7	7.0	13.0	N/A	N/A	N/A	138	102	154
804-2A	3033	2440	3600	1016	480	1320	62	54	80	10.1	8.5	12.8	6.9	5.2	8.5	N/A	N/A	N/A	138	97	154
805-2A	3105	2800	3520	806	560	1280	71	60	80	11.7	9.9	13.7	7.7	6.2	9.0	N/A	N/A	N/A	125	86	153
806-2A	2965	2680	3680	807	680	1080	69	67	73	11.0	10.1	13.2	9.3	7.5	12.5	N/A	N/A	N/A	127	97	150
807-2A	2643	2080	3320	416	160	700	83	76	91	11.6	8.8	13.5	7.6	6.2	8.5	N/A	N/A	N/A	133	96	153
808-2A	2862	2440	3520	773	400	1480	70	53	82	10.6	9.0	11.7	8.9	6.0	14.5	N/A	N/A	N/A	136	88	154
809-2A	3151	2480	3800	682	360	1100	76	60	85	12.7	8.2	14.0	6.7	5.5	8.0	N/A	N/A	N/A	119	94	152
810-2A	2940	2680	3200	463	280	860	82	70	88	12.9	11.7	14.0	8.2	6.5	11.0	N/A	N/A	N/A	138	94	155
811-2A	2747	2120	3320	334	200	560	86	81	90	12.6	10.0	14.3	7.1	5.5	8.5	N/A	N/A	N/A	126	92	154
812-2A	2996	2220	3840	513	300	960	81	71	87	12.9	10.0	15.3	8.2	7.5	9.5	N/A	N/A	N/A	142	95	154
813-2A	2898	2360	3280	536	380	760	79	74	83	12.2	9.4	13.6	7.5	5.6	8.6	N/A	N/A	N/A	145	116	155
814-2A	2589	2100	3080	616	380	840	73	68	82	10.1	8.3	12.3	9.5	8.5	12.5	N/A	N/A	N/A	135	95	154
815-2A	2897	2520	3160	263	200	400	90	86	92	16.6	14.6	17.5	7.4	6.5	8.5	N/A	N/A	N/A	151	140	155
816-2A	2871	2640	3000	251	140	360	90	87	94	16.5	15.8	17.1	7.2	6.6	8.0	N/A	N/A	N/A	131	106	151
817-2A	3050	2840	3200	580	500	680	78	76	82	10.2	9.7	10.8	6.7	2.8	10.0	N/A	N/A	N/A	131	92	154
818-2A	2988	2880	3080	421	390	500	84	82	86	13.4	12.7	14.0	6.7	3.0	10.0	N/A	N/A	N/A	144	120	156
818-2B	3320	2880	4100	547	420	760	81	79	84	14.4	12.6	17.3	7.2	3.0	9.9	N/A	N/A	N/A	148	132	155
819-2A	2742	2160	3060	573	330	800	76	69	86	8.9	7.6	10.1	9.3	6.5	12.2	N/A	N/A	N/A	119	8	152
820-2A	2438	1680	3120	445	130	1000	80	64	91	8.2	6.5	9.3	N/A	N/A	N/A	N/A	N/A	N/A	118	60	152
821-2A	2482	1560	2800	403	100	600	82	76	93	10.8	7.7	11.9	7.7	6.0	10.0	N/A	N/A	N/A	139	93	154

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

RUN NO.	ANALYTICAL POINT	CA++ AVG	CA++ MIN	CA++ MAX	MG++ AVG	MG++ MIN	MG++ MAX	SO3= AVG	SO3= MIN	SO3= MAX	SO4= AVG	SO4= MIN	SO4= MAX	CL- AVG	CL- MIN	CL- MAX
TFG-2A	2816	238	133	440	10346	7639	12139	7889	3844	12213	27818	20544	34713	3284	2570	4121
	2825	316	159	618	10284	8079	12498	7653	4297	10856	28651	21314	37075	3374	2614	4431
TFG-2B	2816	1835	1425	2175	696	631	759	115	67	203	1909	962	2454	3769	3190	4343
	2825	1883	1590	2120	702	633	779	149	67	271	2026	927	2388	3790	3323	4387
TFG-2C	2816	1622	1055	2270	573	345	781	143	67	203	1371	617	2256	3421	2215	4631
	2825	1736	1185	2475	573	333	785	177	45	237	1752	1098	2702	3436	2304	4609
TFG-2D	2816	1394	1220	1710	466	330	539	89	33	158	1797	1306	2486	2546	1905	3080
	2825	1415	1255	1650	470	318	540	164	56	294	1925	1531	2697	2539	1772	3057
TFG-2E	2816	1146	885	1530	470	322	534	107	22	294	1153	554	2066	2536	2189	2969
	2825	1183	932	1545	487	431	569	236	45	644	1388	776	2269	2536	2233	2925
TFG-2F	2816	1633	1190	1990	563	465	647	80	33	158	1868	1121	2307	3317	2836	3944
	2825	1674	1160	2225	608	459	1089	163	33	441	1923	1103	2346	3502	2969	5983
525-2A	2816															
	2825															
526-2A	2816	540	347	616	130	77	187	14	2	25	198	181	225	960	650	1200
	2825	499	353	604	126	102	154	21	18	27	180	163	206	888	665	1080
527-2A	2816															
	2825	494	494	494	103	103	103	23	23	23	248	248	248	860	860	860
528-2A	2816	1382	1014	1632	107	0	265	125	56	272	1471	972	1949	1666	1346	2269
	2825	1111	1052	1170	120	92	148	106	84	128	767	307	1227	1611	1524	1699
529-2A	2816	1883	1883	1883	334	334	334	26	26	26	2046	2046	2046	3261	3261	3261
	2825	1123	1123	1123	141	141	141	272	272	272	908	908	908	1682	1682	1682
530-2A	2816	1581	1007	1915	306	140	443	111	64	232	1721	1147	2098	2534	1489	3332
	2825	1602	1170	2000	277	53	387	136	80	216	1536	1140	1912	2505	1347	3190
531-2A	2816	1121	1040	1165	766	349	1349	213	144	264	2735	2630	2797	1872	1240	2783
	2825	1167	1167	1167	319	319	319	456	456	456	2284	2284	2284	1170	1170	1170
532-2A	2816															
	2825															
533-2A	2816	705	585	760	11191	9260	12780	2512	2017	3370	32767	23063	32767	2970	1914	4183
	2825															
534-2A	2816	2222	2030	2370	170	160	180	68	48	104	1732	1498	1920	3536	3368	3687
	2825	2175	2175	2175	142	142	142	152	152	152	1414	1414	1414	3049	3049	3049
535-2A	2816	1550	800	2250	304	169	410	84	16	184	1870	775	2990	2373	1489	3758
	2825	1250	828	1810	343	190	536	132	16	408	1955	1047	2757	1962	871	3120
535-2B	2816	1104	910	1336	405	372	451	105	56	184	2575	1797	2906	1421	998	1778
	2825															
536-2A	2816	1031	807	1310	426	409	462	86	24	120	2466	1897	3111	1297	1009	1524
	2825	846	810	882	432	427	437	84	56	112	2271	1722	2821	1169	850	1489
537-2A	2816	1450	1207	1755	436	388	480	71	38	128	2222	2158	2325	2455	1914	3111
	2825	1657	1500	1815	449	441	457	155	150	160	2064	2037	2092	2579	2375	2783
538-2A	2816	1370	654	1660	350	276	466	100	0	280	1965	1010	2995	2082	1276	2765
	2825	1308	574	1620	331	284	360	162	48	256	1814	848	2475	1847	1311	2552
539-2A	2816	947	594	1585	284	229	335	82	24	160	741	296	1647	1898	1453	2694

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PH			TOTAL IONS, PPM			PERCENT GYPSUM SATURATION			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
TFG-2A	2816	5.41	5.21	5.67	49720	39540	55236	37	17	77	-0.6	-9.8	8.4
	2825	5.23	4.90	5.62	50425	40606	58890	51	22	110	-2.7	-13.4	8.0
TFG-2B	2816	5.75	5.62	5.83	8414	7281	9826	102	51	141	1.9	-5.1	7.5
	2825	5.19	4.77	5.45	8642	7476	9688	109	49	130	1.3	-7.8	4.9
TFG-2C	2816	5.85	5.71	6.11	7219	4492	10118	76	35	128	2.3	-3.3	8.3
	2825	5.30	5.08	5.75	7763	5250	10885	99	64	156	-0.6	-5.2	2.5
TFG-2D	2816	5.83	5.70	5.91	6394	5746	7422	98	67	148	-0.2	-4.8	4.8
	2825	5.38	5.16	5.53	6614	6101	7493	105	80	162	-2.9	-10.3	0.4
TFG-2E	2816	5.72	5.65	5.81	5536	4332	6923	59	26	115	1.6	-7.5	8.9
	2825	5.07	4.95	5.27	5956	4895	7136	71	39	127	-2.9	-8.1	7.5
TFG-2F	2816	5.70	5.57	5.90	7609	5953	8719	102	55	133	-1.1	-13.6	5.5
	2825	5.19	5.00	5.44	8017	6277	12260	104	54	135	-2.9	-14.9	6.0
525-2A	2816												
	2825												
526-2A	2816	5.86	5.75	6.00	1846	1307	2211	12	11	16	16.1	11.8	17.7
	2825	5.32	5.25	5.40	1718	1323	2066	11	10	13	16.6	12.1	19.9
527-2A	2816												
	2825	5.30	5.30	5.30	1730	1730	1730	16	16	16	9.6	9.6	9.6
528-2A	2816	5.78	5.70	5.85	4893	3654	6432	106	81	134	2.8	-4.8	11.9
	2825	5.23	5.20	5.25	3800	3361	4240	56	22	90	5.6	-3.9	15.1
529-2A	2816	5.75	5.75	5.75	8189	8189	8189	134	134	134	3.4	3.4	3.4
	2825	5.30	5.30	5.30	4263	4263	4263	64	64	64	-0.4	-0.4	-0.4
530-2A	2816	5.83	5.75	6.00	6405	4049	8035	110	72	129	-1.6	-9.6	6.1
	2825	5.37	5.15	5.85	6203	3969	7446	102	72	118	1.1	-4.3	8.2
531-2A	2816	6.00	5.80	6.10	6793	5746	8274	111	78	143	2.0	-9.4	18.7
	2825	5.60	5.60	5.60	5449	5449	5449	124	124	124	-6.6	-6.6	-6.6
532-2A	2816												
	2825												
533-2A	2816				32767	32767	32767	125	101	150	7.3	-5.7	18.6
	2825												
534-2A	2816				7923	7773	8021	132	118	143	-5.7	-13.7	3.0
	2825	5.25	5.25	5.25	7109	7109	7109	112	112	112	4.9	4.9	4.9
535-2A	2816	6.12	5.85	8.60	6299	3984	7932	114	41	164	-2.5	-16.3	18.8
	2825	5.53	5.25	5.95	5751	4471	7061	107	64	155	-5.4	-16.7	12.1
535-2B	2816	5.90	5.85	6.00	5716	4505	6457	125	86	150	-4.7	-15.9	7.9
	2825												
536-2A	2816	5.96	5.90	6.00	5399	4379	6434	115	83	155	-0.1	-8.4	7.8
	2825	5.70	5.60	5.80	4897	4740	5054	94	78	111	-1.9	-6.4	2.6
537-2A	2816	5.90	5.90	5.90	6741	5895	7650	122	114	130	-5.0	-7.0	-3.2
	2825	5.45	5.40	5.50	7382	6942	7823	120	117	124	14.1	13.2	14.9
538-2A	2816	5.94	5.85	6.00	5949	3445	7278	113	48	170	-2.0	-17.5	12.4
	2825	5.61	5.55	5.70	5553	3336	6665	106	42	146	1.4	-8.6	14.1
539-2A	2816	5.99	5.80	6.15	4028	2847	5940	43	18	97	3.0	-8.3	17.1

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

RUN NO.	ANALYTICAL POINT	CA++ AVG	CA++ MIN	CA++ MAX	MG++ AVG	MG++ MIN	MG++ MAX	SO3= AVG	SO3= MIN	SO3= MAX	SO4= AVG	SO4= MIN	SO4= MAX	CL- AVG	CL- MIN	CL- MAX
539-2A	2825	1077	566	1648	312	239	523	111	24	272	881	314	1652	2029	1418	2517
540-2A	2816	757	480	1240	289	242	385	108	40	168	865	307	2416	1439	1099	2127
	2825															
541-2A	2816	608	455	740	295	277	322	132	32	192	744	552	1038	1269	1170	1382
	2825	961	738	1185	288	271	305	148	128	168	1355	987	1724	1489	1418	1560
542-2A	2816	760	587	1075	316	267	361	126	48	216	1130	709	1476	1439	1170	1808
	2825															
543-2A	2816	1417	1405	1430	343	342	345	164	136	192	2332	2233	2432	1797	1219	2375
	2825	1116	1116	1116	375	375	375	216	216	216	2404	2404	2404	1240	1240	1240
544-2A	2816	1277	775	1745	338	296	378	102	40	200	2035	1428	2349	1856	815	2623
	2825	1240	1040	1705	353	296	469	143	88	184	1851	1060	2443	1945	1418	2552
545-2A	2816	1408	1100	1790	345	309	374	114	8	208	1458	1025	1893	2348	1985	2836
	2825	1080	1080	1080	348	348	348	232	232	232	1202	1202	1202	2020	2020	2020
546-2A	2816	1450	1005	2250	191	23	282	81	4	208	1346	368	2247	2199	1560	3332
	2825	1388	1025	1875	194	24	310	142	40	344	1228	340	1745	2155	1666	2836
547-2A	2816	1023	782	1475	276	232	328	116	36	304	655	377	1138	2069	1595	2446
	2825	1038	698	1565	279	245	312	81	24	120	704	358	1204	2180	1489	2659
548-2A	2816	961	507	1495	123	100	142	99	48	152	525	225	1008	1375	850	1701
	2825	1185	1025	1345	126	99	153	180	144	216	697	214	1181	1754	1737	1772
549-2A	2816	1582	1200	1975	142	101	167	80	24	144	865	620	1120	2467	1701	3084
	2825	1548	1205	1910	138	96	166	96	24	144	855	591	1033	2460	1595	3084
550-2A	2816	1958	1245	2845	204	143	245	91	40	176	1001	454	1644	3079	2517	3722
	2825	1800	1405	2195	228	224	233	100	80	120	829	547	1111	2765	2481	3049
551-2A	2816	1070	1010	1160	244	232	251	96	40	176	398	291	462	2257	2162	2340
	2825	1020	1015	1025	221	180	262	132	96	168	331	262	400	2020	1843	2198
552-2A	2816	861	765	965	259	249	269	129	92	184	286	84	443	2118	1985	2269
	2825	897	897	897	248	248	248	144	144	144	363	363	363	2091	2091	2091
553-2A	2816	1479	1455	1503	268	265	272	272	176	368	1407	1402	1412	2286	2233	2340
	2825															
554-2A	2816	1135	1070	1200	298	267	330	48	32	64	1011	861	1161	2057	1915	2199
	2825															
555-2A	2816	1327	1105	1535	170	162	191	62	48	88	1372	1038	1890	1745	1524	2056
	2825	1550	1550	1550	202	202	202	88	88	88	1011	1011	1011	1914	1914	1914
556-2A	2816	1450	1190	1580	217	139	260	84	8	120	1638	1460	1969	2121	1134	2446
	2825	1444	1299	1590	238	219	258	88	48	128	1574	1411	1738	2251	2127	2375
557-2A	2816	1016	725	1438	279	231	318	87	8	144	1380	700	1920	1674	1240	2127
	2825	1137	902	1319	264	216	312	173	136	216	1644	1497	1845	1737	1630	1808
558-2A	2816	1060	640	1680	332	211	434	105	16	216	1598	641	2603	1666	1099	2375
	2825	1141	762	1745	315	223	384	148	48	272	1741	1282	2586	1622	921	2304
559-2A	2816	920	508	1570	363	288	449	98	8	336	1403	573	2714	1772	1311	2800
	2825	745	530	1110	362	291	428	116	32	304	1170	693	2227	1506	1276	1737
560-2A	2816	856	662	1030	356	306	424	50	24	136	927	479	1355	1991	1772	2269
	2825															

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PH			TOTAL IONS, PPM			PERCENT GYPSUM SATURATION			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
539-2A	2825	5.66	5.40	5.90	4490	2719	5965	52	15	97	4.6	-7.0	17.8
540-2A	2816	5.96	5.55	6.50	3531	2693	5368	45	14	122	4.1	-1.9	9.1
	2825												
541-2A	2816	5.88	5.85	5.90	3118	2937	3551	35	22	53	4.0	-6.5	11.3
	2825	5.60	5.60	5.60	4318	3644	4992	75	49	102	0.4	0.1	0.6
542-2A	2816	5.89	5.85	5.95	3848	3484	4710	55	37	79	-1.4	-6.5	3.0
	2825												
543-2A	2816	5.85	5.80	5.90	6145	5646	6644	134	129	140	-1.3	-16.3	13.7
	2825	5.40	5.40	5.40	5437	5437	5437	122	122	122	-1.3	-1.3	-1.3
544-2A	2816	5.99	5.90	6.15	5695	3607	6947	114	70	137	-2.7	-11.4	13.2
	2825	5.53	5.40	5.85	5619	4875	7276	103	63	153	-3.1	-11.3	10.5
545-2A	2816	5.93	5.85	6.00	5763	4761	6834	88	58	118	2.1	-2.1	5.2
	2825	5.50	5.50	5.50	4965	4965	4965	67	67	67	-2.9	-2.9	-2.9
546-2A	2816	5.83	5.60	6.10	5363	3793	7657	94	24	162	-1.4	-16.6	10.6
	2825	5.39	5.25	5.55	5198	4043	6604	85	21	133	-2.0	-15.3	15.8
547-2A	2816	5.95	5.85	6.00	4240	3509	5435	40	22	78	2.6	-2.3	16.1
	2825	5.48	5.45	5.50	4381	3398	5882	42	21	83	-0.1	-1.8	1.3
548-2A	2816	6.00	5.90	6.10	3138	1918	4486	38	14	78	12.7	7.9	17.2
	2825	5.55	5.45	5.65	4012	3390	4634	52	16	89	5.3	-2.0	12.5
549-2A	2816	5.88	5.80	6.00	5205	4090	6107	65	46	82	3.4	-0.9	9.9
	2825	5.40	5.35	5.45	5166	4014	6197	65	44	80	1.8	-5.1	7.9
550-2A	2816	5.82	5.55	5.95	6432	4701	8611	76	31	133	5.6	-4.8	15.0
	2825	5.35	5.35	5.35	5821	4833	6810	62	39	85	12.3	9.7	14.9
551-2A	2816	5.93	5.85	6.00	4149	3868	4449	26	19	30	2.7	-0.9	6.8
	2825	5.60	5.60	5.60	3795	3676	3914	22	17	28	6.0	5.1	6.8
552-2A	2816	5.99	5.95	6.05	3739	3378	4125	17	5	27	-2.4	-4.3	1.7
	2825	5.50	5.50	5.50	3822	3822	3822	22	22	22	-3.4	-3.4	-3.4
553-2A	2816	5.83	5.75	5.90	5818	5817	5819	92	92	93	-1.3	-3.9	1.4
	2825												
554-2A	2816	5.98	5.95	6.00	4684	4654	4714	60	52	69	6.2	1.9	10.4
	2825												
555-2A	2816	5.94	5.85	6.10	4741	4197	5232	94	73	132	3.6	-4.1	11.6
	2825	5.55	5.55	5.55	4829	4829	4829	73	73	73	19.7	19.7	19.7
556-2A	2816	5.96	5.85	6.15	5596	4367	6302	109	95	129	-2.8	-10.3	3.1
	2825	5.85	5.10	6.60	5691	5572	5810	104	89	119	-4.2	-11.3	2.9
557-2A	2816	5.95	5.85	6.05	4535	3485	5865	79	38	122	-1.4	-10.4	6.0
	2825	5.47	5.29	5.65	5058	4582	5470	97	78	118	-7.0	-8.6	-4.5
558-2A	2816	5.84	5.60	6.10	4870	3583	6976	87	31	153	0.6	-12.1	17.6
	2825	5.39	4.95	5.90	5071	3416	7152	97	61	160		-11.9	16.7
559-2A	2816	5.84	5.35	6.30	4664	3161	6556	71	22	150	-3.2	-13.7	9.7
	2825	5.40	5.20	5.75	4007	3261	5059	55	27	122	0.6	-11.7	13.0
560-2A	2816	5.61	5.20	6.20	4296	3634	4852	47	25	70	-1.4	-11.1	10.4
	2825												

RUN SUMMARY - LIQUID ANALYTICAL DATA

, CONCENTRATIONS IN LIQUID, PPM

RUN NO.	ANALYTICAL POINT	CA++			MG++			SO3=			SO4=			CL-		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
561-2A	2816	1344	864	2250	363	328	417	74	8	288	1040	595	1676	2592	1950	3332
	2825															
562-2A	2816	1233	679	2700	364	319	451	74	8	160	775	240	2534	2624	1772	3545
	2825															
562-2B	2816	1598	1305	2280	403	345	445	112	16	168	1038	451	1734	2935	2481	3442
	2825															
563-2A	2816	777	378	1295	373	317	416	120	52	192	568	321	941	2002	1347	2783
	2825															
564-2A	2816	1256	1017	1365	404	372	491	128	80	224	2363	2169	2663	2082	1772	2304
	2825															
565-2A	2816	1170	910	1355	382	320	461	581	432	678	1887	1252	2669	1706	1560	1808
	2825															
566-2A	2816	1245	784	1780	490	327	598	119	56	488	1311	658	2097	2493	1879	3226
	2825															
567-2A	2816	843	584	1140	415	307	501	73	24	192	812	544	1684	2005	1524	2410
	2825															
568-2A	2816	848	677	1032	447	418	498	120	28	208	1715	1267	2244	1729	1595	1915
	2825															
569-2A	2816	1271	960	1971	522	410	712	120	72	176	2251	2095	2391	2269	1347	3124
	2825															
569-2B	2816	1331	1220	1460	451	425	502	148	24	240	2266	2087	2448	1888	1545	2588
	2825															
570-2A	2816	1437	1140	1930	492	429	576	69	32	104	2216	2021	2695	2400	1950	3226
	2825															
571-2A	2816	1680	1540	1930	486	417	559	113	64	180	2144	1788	2575	2880	2552	3510
	2825															
571-2B	2816															
	2825															
572-2A	2816	1707	1320	2155	484	407	540	224	72	424	2031	1652	2228	3051	2304	4077
	2825															
573-2A	2816	2215	1970	2375	616	577	647	106	72	144	1951	1725	2168	3888	3616	4148
	2825															
575-2A	2816	2008	1690	2320	568	517	616	106	24	144	1759	1629	1891	3589	3190	4006
	2825															
576-2A	2816	1971	1575	2300	537	471	609	116	32	208	1546	1025	2078	3862	3403	4148
	2825															
576-2B	2816															
	2825															
577-2A	2816	1556	1200	2250	512	429	588	76	24	248	1290	1030	1808	3488	3084	4219
	2825															
578-2A	2816															
	2825															
579-2A	2816	1549	1435	1665	529	471	591	403	248	632	2198	2059	2364	2743	2446	3261

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PH			TOTAL IONS, PPM			PERCENT GYPSUM SATURATION			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
561-2A	2816 2825	5.90	5.70	6.20	5520	4214	7859	63	33	113	3.1	-4.6	13.2
562-2A	2816 2825	5.91	5.75	6.10	5169	3556	9237	46	15	173	2.6	-11.9	18.6
562-2B	2816 2825	5.72	5.50	5.85	6208	5145	8110	65	29	113	8.4	2.4	17.4
563-2A	2816 2825	5.96	5.75	6.15	3946	2592	5401	27	14	56	1.5	-10.1	16.1
564-2A	2816 2825	5.26	5.10	5.40	6342	5688	6780	124	112	145	-12.1	-16.9	-0.3
565-2A	2816 2825	5.24	5.15	5.30	5817	4772	6778	100	64	142	-10.1	-14.7	0.7
566-2A	2816 2825	5.82	5.15	6.00	5761	4518	7114	70	29	126	4.6	-11.9	15.2
567-2A	2816 2825	5.96	5.85	6.05	4244	3217	5219	38	23	84	4.6	-3.5	17.0
568-2A	2816 2825	5.59	5.47	5.86	4953	4386	5533	74	54	104	-6.8	-17.6	6.2
569-2A	2816 2825	5.50	5.36	5.60	6551	5279	8122	109	91	132	-4.0	-11.8	6.9
569-2B	2816 2825	5.50	5.47	5.56	6182	5927	6706	118	114	128	2.4	-4.5	10.7
570-2A	2816 2825	5.77	5.65	5.85	6725	5913	7857	117	101	150	-0.1	-9.6	10.3
571-2A	2816 2825	5.79	5.68	5.89	7413	6998	8127	122	110	140	-1.0	-6.2	3.1
571-2B	2816 2825												
572-2A	2816 2825	5.23	5.15	5.40	7614	6302	8920	117	94	127	-4.1	-12.0	1.1
573-2A	2816 2825	5.51	5.48	5.54	8913	8632	9452	117	107	131	7.3	-1.9	19.6
575-2A	2816 2825	5.55	5.49	5.68	8157	7396	8874	105	95	118	7.1	3.6	14.8
576-2A	2816 2825	5.63	5.48	5.76	8166	6873	9243	94	56	136	2.0	-6.1	9.5
576-2B	2816 2825												
577-2A	2816 2825	5.86	5.67	6.21	7041	6213	8957	73	55	116	-3.5	-10.6	15.9
578-2A	2816 2825												
579-2A	2816	5.22	5.12	5.35	7530	6873	8079	118	112	126	-7.1	-10.8	-3.9

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

RUN	ANALY	CA++			MG++			SO3=			SO4=			CL-		
NO.	TICAL POINT	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
579-2A	2825															
580-2A	2816	1415	1415	1415	509	509	509	320	320	320	2595	2595	2595	2410	2410	2410
	2825															
581-2A	2816	1894	1025	2700	473	391	535	103	11	316	2109	1626	2597	3428	1099	4786
	2825															
582-2A	2816	2579	2579	2579	549	549	549	22	22	22	1840	1840	1840	3900	3900	3900
	2825															
583-2A	2816	1833	1228	2260	2637	2079	3309	415	180	904	5382	3815	7542	7090	5318	8863
	2825															
583-2B	2816	765	644	1132	6829	5239	11359	2838	1040	7237	19588	14202	27958	4115	2304	6381
	2825															
584-2A	2816	362	142	730	10600	5799	13878	7476	452	20807	27308	12692	32767	5012	2659	8154
	2825															
585-2A	2816	644	435	752	10569	8599	13373	3996	1990	5428	31523	27077	32767	4176	3190	6913
	2825															
586-2A	2816	497	222	798	9991	8199	11639	6907	2442	18545	25923	12212	32767	4368	3013	6027
	2825															
587-2A	2816	662	218	900	9885	8279	11839	5848	2623	11534	30885	23183	32767	2027	1240	3190
	2825															
588-2A	2816	775	624	916	11418	10139	13658	3179	904	5428	31722	26604	32767	6337	4077	9484
	2825															
589-2A	2816	676	584	874	10534	8779	13358	3658	226	6083	32767	28273	32767	3652	1063	9661
	2825															
590-2A	2816	1465	1350	1540	356	350	364	768	508	927	1827	1311	2174	1875	1772	1950
	2825	1521	1390	1650	316	306	325	942	848	1017	2160	1740	2389	1801	1772	1861
590-2B	2816	1455	1220	1670	389	304	450	251	113	395	1967	1733	2168	1858	1595	2038
	2825	1545	1315	1800	392	305	430	497	226	870	2014	1490	2290	1851	1595	1994
591-2A	2816	620	582	726	5372	4199	6209	2008	904	3222	19296	17036	21792	1400	1152	1905
	2825	674	588	780	5300	4399	5839	2773	1379	4127	18974	17052	21810	1414	1196	1950
592-2A	2816	605	419	762	9735	9199	10379	4376	3110	5880	31128	28443	34998	2526	2127	3589
	2825	660	435	868	9645	8819	10520	5095	2827	6729	30477	24186	35670	2550	2082	3816
593-2A	2816	556	400	734	10301	9480	11600	4536	2657	7803	31193	27359	36693	3819	3106	4482
	2825	619	408	842	10126	9000	11760	5595	3449	10404	30179	25876	36445	3853	3151	4748
594-2A	2816	557	352	664	10175	9400	10760	5371	1640	7859	30554	27392	33121	3574	3062	4571
	2825	650	384	834	10006	9060	10600	6420	2714	8255	30109	26761	33422	3648	3106	4659
601-2A	2816	420	130	688	2537	1011	3489	438	90	1040	7967	3506	9515	1506	709	2570
	2825															
602-2A	2816	351	140	788	2898	2529	3339	425	171	814	7731	6549	9272	2587	2304	3102
	2825															
603-2A	2816	623	307	840	3198	2534	3759	395	203	723	8663	7599	10752	3106	2659	3988
	2825															
604-2A	2816	723	624	850	3103	2874	3504	279	180	452	8308	7263	9257	3101	2304	3545
	2825															

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PH			TOTAL IONS, PPM			PERCENT GYPSUM SATURATION			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
579-2A	2825												
580-2A	2816	5.86	5.86	5.86	7351	7351	7351	133	133	133	-12.3	-12.3	-12.3
	2825												
581-2A	2816	5.49	5.21	5.62	8116	5390	10026	125	100	145	-4.5	-12.6	6.0
	2825												
582-2A	2816	5.35	5.35	5.35	9010	9010	9010	122	122	122	16.3	16.3	16.3
	2825												
583-2A	2816	5.54	5.37	5.75	17592	14786	21225	139	111	187	-2.4	-6.9	2.4
	2825												
583-2B	2816	5.32	4.98	5.70	32767	26482	32767	111	95	175	1.6	-14.0	12.0
	2825												
584-2A	2816	5.50	5.16	5.98	32767	31944	32767	56	13	118	-0.3	-10.6	10.8
	2825												
585-2A	2816	5.36	5.21	5.54	32767	32767	32767	107	72	124	3.1	-10.2	12.3
	2825												
586-2A	2816	5.34	5.16	5.54	32767	32767	32767	73	26	129	2.0	-9.6	18.4
	2825												
587-2A	2816	5.35	4.98	5.90	32767	32767	32767	113	30	149	0.1	-13.8	14.0
	2825												
588-2A	2816	5.41	5.12	5.78	32767	32767	32767	122	104	159	6.9	-5.2	13.5
	2825												
589-2A	2816	5.41	5.25	5.70	32767	32767	32767	117	101	153	2.3	-11.2	12.1
	2825												
590-2A	2816	5.07	4.94	5.16	6407	5824	6839	109	79	129	-3.5	-6.8	-0.4
	2825	4.87	4.73	4.95	6861	6260	7267	132	106	148	-12.6	-15.0	-11.1
590-2B	2816	5.28	5.02	5.48	6037	5411	6661	113	104	127	7.9	-3.3	12.6
	2825	5.07	4.82	5.33	6414	5980	7310	118	94	130	5.4	-9.9	13.8
591-2A	2816	5.47	5.23	5.75	28837	24037	32605	104	92	123	-3.0	-8.8	3.7
	2825	5.30	5.07	5.67	29276	24892	32592	112	89	126	-6.3	-13.1	1.6
592-2A	2816	5.40	5.10	5.64	48479	44848	52378	105	73	138	0.7	-9.7	12.7
	2825	5.18	4.92	5.41	48534	43054	54977	113	64	158	-0.5	-14.3	13.2
593-2A	2816	5.45	5.20	5.70	50530	46318	57037	93	68	129	0.8	-8.9	14.8
	2825	5.24	5.00	5.80	50500	45671	59078	102	66	143	-1.1	-11.3	6.9
594-2A	2816	5.36	5.10	5.60	50354	46326	54018	92	59	112	-0.2	-5.8	8.8
	2825	5.14	4.90	5.40	50954	46367	56372	107	68	136	-3.5	-12.1	6.0
601-2A	2816	7.09	6.04	7.71	12937	6075	15512	58	17	97	5.0	-10.6	15.8
	2825												
602-2A	2816	6.92	6.58	7.39	14061	12096	15562	43	19	93	4.9	-12.9	13.7
	2825												
603-2A	2816	6.92	6.04	7.66	16084	14151	18701	76	38	109	6.1	-10.2	15.1
	2825												
604-2A	2816	6.89	6.61	7.11	15633	14302	17408	86	75	103	9.3	3.3	15.7
	2825												

RUN SUMMARY - LIQUID ANALYTICAL DATA , CONCENTRATIONS IN LIQUID, PPM

RUN NO.	ANALYTICAL POINT	* CA++			MG++			SO3=			SO4=			CL-		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
605-2A	2816	371	207	592	3063	2429	3454	394	135	678	8126	6828	9362	2694	2393	3013
	2825															
606-2A	2816	716	628	836	2887	2519	3159	278	45	407	8721	7046	9525	2499	1861	2836
	2825															
607-2A	2816	492	75	760	4859	3629	5979	771	271	2058	15002	9953	17594	2581	2304	3013
	2825	926	850	1034	5032	4909	5179	2701	2668	2723	16316	15026	17543	2540	2481	2659
608-2A	2816	593	80	944	4818	4389	5219	632	280	2284	14725	10905	16438	2312	1950	2659
	2825	805	652	1094	4961	4649	5559	2538	1899	3075	16362	13368	21964	2175	1861	2659
608-2B	2816	121	5	406	4928	4059	5899	2779	384	6083	11530	9438	13840	2974	1879	4431
	2825	183	55	353	4833	4509	5129	4712	2917	6468	11488	8160	13852	3332	3013	4077
609-2A	2816	417	64	782	3536	2809	4630	700	226	2691	9482	7290	11796	3510	2840	4609
	2825	785	169	1212	3668	2929	4369	2588	1809	4161	10067	7677	11966	3496	2481	4875
610-2A	2816	339	106	878	3379	2869	4069	668	271	1176	8276	7141	9684	3515	2659	5052
	2825	659	282	1082	3385	3019	3859	2105	1311	2849	8625	6815	10269	3567	2747	4343
611-2A	2816	859	255	1254	3873	3333	4319	300	113	520	9445	8127	10360	5186	4609	6204
	2825	1155	1048	1384	3769	3539	4329	1628	1334	1967	9667	9037	10797	5282	5052	5584
612-2A	2816	869	760	998	4056	3419	4629	302	90	542	9638	6964	10913	5598	4786	6027
	2825	1124	1054	1166	4290	3879	4709	2117	1809	2736	10233	9919	10742	5908	5672	6204
613-2A	2816	834	628	930	4101	3499	4539	278	226	361	9812	9286	10668	5554	4609	6293
	2825	1048	966	1156	3969	3549	4599	1808	1221	2193	9955	9440	10307	5140	4857	5672
614-2A	2816	749	107	926	3470	2719	3900	392	248	1357	8891	8047	9791	4236	2127	5229
	2825															
615-2A	2816	783	600	966	3734	3149	4109	305	113	497	9718	8017	11173	4482	3900	5140
	2825	1133	1025	1430	3690	3129	4059	1679	1176	2353	9933	8242	11053	4595	4148	5495
616-2A	2816	2701	1700	3255	219	80	342	136	45	339	1498	580	2200	4056	2481	5140
	2825	3108	2775	3520	229	91	375	1278	361	1854	1989	1147	3252	4106	2659	5229
617-2A	2816	2735	2010	3860	521	353	643	124	0	226	1560	827	1923	4588	3651	6115
	2825	3046	2600	4370	521	355	678	994	90	1402	2170	631	3279	4653	3634	6115
618-2A	2816	1620	1500	1915	361	319	429	83	22	135	1985	1786	2214	2327	1861	2659
	2825	1924	1665	2175	373	337	414	861	271	1323	2435	1930	2650	2350	2171	2605
618-2B	2816	1551	1375	1905	382	347	444	83	11	169	1993	1787	2191	2400	2215	2659
	2825	1662	1350	2150	378	342	424	424	11	1017	2161	1994	2622	2381	2127	2659
619-2A	2816	569	100	708	3124	2599	3999	407	158	1492	10778	9210	12778	2155	1728	2481
	2825	696	116	960	3113	2579	4229	1103	214	1956	10842	9054	13642	2159	1772	2481
620-2A	2816	628	524	746	2733	2329	3289	330	248	418	9861	8865	11719	1883	1329	2393
	2825	727	580	810	2725	2349	3139	914	237	1922	10057	8308	12461	1882	1506	2393
621-2A	2816	660	528	850	2686	2139	3124	312	147	452	10185	8051	11437	1600	1285	2082
	2825	799	575	1090	2694	2229	3049	1025	294	2148	10084	8052	11814	1600	1240	2082
622-2A	2816	622	220	1076	5280	3310	8160	938	565	1470	17207	12019	26052	2236	1598	3239
	2825	724	292	1070	5274	3120	7780	2092	1018	2601	16801	11584	25066	2285	1598	3417
622-2B	2816	707	636	844	2665	2380	2960	465	113	1153	8852	8034	10044	1491	1331	1731
	2825	970	826	1052	2674	2230	3030	1301	498	1922	9137	8250	10158	1526	1287	1775
623-2A	2816	510	158	900	2742	2320	3400	411	181	746	9022	7740	11918	1616	1021	2130

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PH			TOTAL IONS, PPM			PERCENT GYPSUM SATURATION			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
605-2A	2816	6.95	6.79	7.10	14754	13271	16274	46	24	79	6.7	-3.4	12.3
	2825												
606-2A	2816	7.95	7.83	8.21	15192	13506	16247	93	82	112	6.1	-2.4	9.8
	2825												
607-2A	2816	7.94	7.67	8.20	23789	17497	27537	73	11	111	5.0	-11.6	15.6
	2825	5.15	5.06	5.24	27606	26067	29046	138	127	160	-3.4	-5.8	0.4
608-2A	2816	7.94	7.75	8.20	23170	20830	24731	87	9	135	9.3	-2.0	17.4
	2825	5.03	5.02	5.06	26934	24075	32767	125	89	194	-2.6	-14.7	4.1
608-2B	2816	7.95	7.83	8.10	22421	18206	26570	15	1	51	5.0	-6.3	14.9
	2825	5.84	5.48	6.19	24632	23061	26409	21	7	35	-10.1	-14.5	-6.8
609-2A	2816	7.01	6.82	8.11	17744	14409	21745	52	8	96	0.2	-11.7	12.9
	2825	4.96	4.83	5.08	20701	17934	23155	96	22	157	-8.4	-14.8	0.2
610-2A	2816	7.96	7.73	8.17	16285	14290	19501	40	12	105	3.1	-13.5	11.7
	2825	5.44	5.06	7.97	18447	16072	21309	77	29	134	-5.9	-12.2	-1.3
611-2A	2816	7.96	7.78	8.11	19802	18179	20907	96	30	138	4.0	-11.5	10.7
	2825	5.07	4.87	5.17	21630	20334	23237	130	120	155	-5.3	-11.9	-0.5
612-2A	2816	7.96	7.81	8.15	20620	17653	22636	96	76	109	4.1	-1.1	13.3
	2825	4.91	4.58	5.24	23836	22790	24688	123	114	139	-4.7	-9.9	3.1
613-2A	2816	6.88	6.74	7.10	20719	18779	22187	93	77	108	3.8	-4.0	10.2
	2825	4.87	4.68	5.02	22063	20233	23893	119	116	122	-4.2	-11.6	3.6
614-2A	2816	8.12	7.83	8.56	17849	14411	19482	86	15	104	3.2	-13.2	10.9
	2825												
615-2A	2816	7.07	6.86	7.50	19162	17489	20428	92	77	100	3.9	-7.3	10.6
	2825	4.95	4.77	5.07	21169	19578	22707	133	112	154	-4.0	-14.1	5.2
616-2A	2816	7.92	5.74	8.32	8763	6041	10208	117	50	171	5.1	-5.4	14.0
	2825	4.38	4.12	4.73	10867	8963	12165	157	94	259	-5.9	-17.0	9.5
617-2A	2816	7.99	7.70	8.14	9690	7637	12317	107	52	123	10.2	-0.9	15.1
	2825	4.67	4.32	7.95	11566	8389	14478	150	48	233	-0.6	-14.6	16.7
618-2A	2816	6.97	6.40	7.67	6497	6204	6974	121	110	136	4.6	-5.9	14.0
	2825	4.97	4.75	5.50	8064	7464	8691	154	133	170	-6.4	-14.5	5.2
618-2B	2816	6.97	5.73	7.37	6537	6262	7083	118	102	133	1.3	-5.1	13.7
	2825	5.76	5.16	8.20	7139	6224	8390	130	115	163	-3.9	-11.7	7.2
619-2A	2816	6.94	5.21	8.08	17162	14711	20696	85	15	114	-2.1	-15.1	5.9
	2825	5.77	5.14	7.00	18050	15700	21972	102	17	143	-6.6	-14.9	3.6
620-2A	2816	7.19	6.68	8.16	15559	13874	17797	94	82	116	-2.9	-10.6	9.2
	2825	5.84	4.79	7.36	16433	14966	18443	109	94	122	-8.1	-14.5	8.7
621-2A	2816	7.04	6.65	7.75	15578	12698	17498	103	74	128	-2.8	-12.9	11.3
	2825	5.62	5.15	6.41	16338	14344	18036	120	86	149	-5.7	-14.4	6.6
622-2A	2816	6.95	6.50	7.20	26374	18634	39655	97	36	170	4.4	-3.9	11.7
	2825	5.54	5.20	6.70	27269	19354	39455	109	47	170	0.6	-12.1	13.4
622-2B	2816	6.85	5.90	7.10	14263	13162	15290	98	88	114	7.3	-2.5	12.0
	2825	5.48	5.20	6.00	15693	13854	16566	132	116	149	1.7	-11.6	9.0
623-2A	2816	7.04	6.45	7.90	14391	12085	17876	72	23	130	3.8	-8.6	14.9

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

RUN NO.	ANALYTICAL POINT	CA++ AVG	CA++ MIN	CA++ MAX	MG++ AVG	MG++ MIN	MG++ MAX	SO3= AVG	SO3= MIN	SO3= MAX	SO4= AVG	SO4= MIN	SO4= MAX	CL- AVG	CL- MIN	CL- MAX
623-2A	2825	670	356	1000	2671	2230	3370	1414	633	4071	8972	5848	11641	1616	932	2130
624-2A	2816	522	206	962	2641	2140	3180	478	204	882	7963	6799	9113	2014	1598	2840
	2825	861	330	1332	2587	2100	3160	1777	1221	2330	8205	6996	9595	2014	1598	2884
625-2A	2816	1497	838	2380	360	136	560	153	23	588	1806	863	2724	2165	1154	3728
	2825	1698	1130	2475	371	51	578	850	204	1447	1970	806	2737	2140	1154	3550
701-2A	2816	1711	979	3419	291	69	511	132	22	1198	726	213	2898	3127	2127	4254
	2825	1670	1025	2240	289	72	495	117	22	271	712	213	2417	3079	1950	4077
702-2A	2816	1074	612	1455	599	413	839	64	22	203	458	67	1238	3040	1772	3944
	2825	1081	590	1557	614	414	879	101	22	452	509	269	1247	3089	1701	4254
703-2A	2816	1197	700	1790	545	473	619	142	33	361	459	218	845	3178	2149	3988
	2825	1246	712	1755	551	467	622	354	90	723	584	165	989	3220	2171	4033
704-2A	2816	1499	1035	2195	557	203	629	144	22	407	1261	326	2579	3169	1418	4143
	2825	1570	1055	2385	552	217	664	386	113	995	1393	368	3045	3195	1462	4121
705-2A	2816	1244	677	1875	633	524	714	139	45	384	1280	420	3029	2856	1861	3678
	2825	1277	689	1910	639	539	738	236	67	497	1304	284	3045	2902	1994	3722
706-2A	2816	1719	1320	2310	687	542	837	125	22	350	2301	1944	2754	3230	1728	4653
	2825	1798	1305	2330	703	556	831	234	45	859	2450	1867	3170	3323	2526	4431
707-2A	2816	1406	1125	2155	551	475	637	100	11	192	1904	1404	2421	2825	2082	4099
	2825	1426	1150	2070	548	479	655	121	11	226	1913	1470	2193	2854	2105	3855
708-2A	2816	1368	1190	1545	453	325	559	403	248	680	2222	1604	2805	1971	1598	2304
	2825	1534	1370	1790	470	331	575	829	463	1337	2380	1834	3333	2013	1644	2393
709-2A	2816	1229	1050	1405	411	345	449	311	45	633	2089	1821	2680	1671	1506	1905
	2825	1317	1055	1535	402	346	477	625	260	1121	2154	1836	2606	1700	1506	1950
710-2A	2816	1325	1060	1677	443	360	519	305	56	667	2087	1710	2659	1729	1063	2260
	2825	1459	1215	1700	441	285	524	725	350	995	2252	1569	2720	1686	1107	2149
711-2A	2816	1243	1020	1570	486	452	551	93	45	147	1524	1170	1979	2184	2038	2348
	2825	1587	1485	1690	472	467	478	158	158	158	1989	1979	1999	2270	2215	2326
712-2A	2816	991	618	1390	436	290	542	93	33	147	1273	741	2249	1990	1506	2304
	2825	1003	618	1445	427	299	561	134	56	271	1299	738	2156	1980	1373	2504
713-2A	2816	965	782	1300	372	307	416	133	22	452	1995	1610	2580	1146	886	1772
	2825	980	795	1252	375	306	440	149	33	260	2066	1604	2705	1152	797	1772
714-2A	2816	988	264	1540	493	288	642	164	56	407	1638	536	2775	1757	753	2623
	2825	1007	258	1685	481	258	699	166	45	316	1720	560	2747	1741	753	2597
714-2B	2816	306	260	374	254	189	392	120	22	178	551	359	722	761	531	1373
	2825	317	204	391	294	214	380	116	79	147	662	622	695	930	531	1418
715-2A	2816	1402	1095	1670	427	371	565	123	33	203	1800	1464	2085	2307	1595	3279
	2825	1414	1035	1717	415	365	499	192	67	357	1892	1532	2378	2223	1595	2836
716-2A	2816	1391	1180	1725	414	366	481	142	56	214	1963	1711	2114	2107	1595	2659
	2825	1424	1240	1755	414	357	496	211	113	452	2109	1831	2621	2099	1551	2535
717-2A	2816	1238	452	1905	441	329	696	135	45	260	1689	688	2661	2125	1347	3235
	2825	1260	459	1930	437	329	688	173	45	395	1758	713	2793	2095	1329	2969
718-2A	2816	1494	1165	1880	453	384	506	124	56	180	2001	1795	2324	2366	1905	3013
	2825															

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PH			TOTAL IONS, PPM			PERCENT GYPSUM SATURATION			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
623-2A	2825	5.37	4.70	5.79	15432	12510	18705	94	52	148	-4.8	-14.2	9.2
624-2A	2816	7.03	6.70	7.30	13717	11883	16332	68	28	127	4.5	-10.9	12.4
	2825	5.16	4.90	5.60	15547	13782	17746	112	44	181	-5.4	-16.8	7.5
625-2A	2816	7.98	5.70	9.00	6078	3653	8696	108	52	170	4.4	-9.6	15.3
	2825	5.15	4.50	6.10	7127	4941	9740	122	51	161	-3.8	-13.4	15.2
701-2A	2816	5.80	5.00	7.98	6090	4065	10787	50	17	235	4.8	-12.5	14.1
	2825	5.20	4.96	5.78	5968	4262	8347	48	17	171	5.0	-8.6	14.5
702-2A	2816	5.85	5.54	6.08	5308	3219	6642	21	3	64	8.0	-11.1	14.7
	2825	5.28	4.91	5.50	5469	3209	7090	23	12	65	6.1	-15.0	14.4
703-2A	2816	5.67	5.40	5.91	5580	3820	6985	24	11	41	3.4	-12.1	10.5
	2825	5.08	4.79	5.36	6015	4043	7054	30	8	49	-2.3	-14.5	6.1
704-2A	2816	5.67	5.20	6.10	6679	4882	9149	70	16	151	2.9	-11.4	13.8
	2825	4.99	4.50	5.45	7146	5029	10367	79	19	187	-2.3	-13.9	9.7
705-2A	2816	5.85	5.66	5.95	6200	4246	8537	62	16	162	4.5	-4.7	14.9
	2825	5.20	4.92	5.43	6406	4349	8892	64	11	166	2.6	-8.1	14.1
706-2A	2816	5.55	5.17	6.00	8125	6102	9996	118	97	153	1.6	-12.9	15.0
	2825	5.07	4.65	5.58	8572	7216	10049	126	99	155	-0.7	-13.8	10.4
707-2A	2816	5.59	5.43	5.79	6848	5604	9417	98	66	147	-3.4	-12.3	2.5
	2825	5.21	5.00	5.45	6926	5729	8862	99	70	134	-4.1	-11.6	1.7
708-2A	2816	5.21	5.02	5.40	6515	5508	6951	118	86	143	-3.0	-12.0	3.4
	2825	4.92	4.68	5.33	7325	6529	8225	130	103	177	-7.3	-14.2	-1.8
709-2A	2816	5.34	4.89	5.54	5813	5142	6519	109	88	143	-0.3	-10.4	14.0
	2825	4.97	4.63	5.12	6305	5187	7530	117	90	142	-6.3	-14.9	10.1
710-2A	2816	5.41	5.16	5.77	5994	4836	6894	110	84	131	5.9	-7.1	19.2
	2825	4.93	4.57	5.28	6667	5132	7601	124	89	149	0.1	-6.6	12.1
711-2A	2816	5.65	5.43	5.83	5636	5002	6369	79	57	107	9.2	2.4	13.0
	2825	5.02	4.96	5.07	6576	6435	6718	113	110	116	9.9	7.5	12.2
712-2A	2816	5.85	5.64	6.04	4890	3414	6362	62	33	118	4.0	-10.7	16.4
	2825	5.16	5.00	5.40	4949	3249	6889	64	36	110	2.8	-9.5	16.0
713-2A	2816	5.73	5.60	5.92	4664	3960	5689	96	73	136	4.2	-5.0	11.3
	2825	5.26	5.14	5.40	4777	4041	5816	100	75	141	3.0	-10.0	11.8
714-2A	2816	5.76	5.46	6.04	5209	2016	6849	75	17	124	8.0	-12.5	14.2
	2825	5.31	3.62	5.79	5284	1933	7538	80	18	141	6.5	-10.4	13.7
714-2B	2816	6.13	6.03	6.19	2075	1585	3011	19	13	27	9.0	0.5	17.2
	2825	5.77	5.70	5.87	2415	1710	3082	21	18	26	1.2	-6.4	10.0
715-2A	2816	5.74	5.52	5.98	6175	5015	7436	100	75	118	3.1	-2.9	13.7
	2825	5.22	5.00	5.58	6257	5071	7313	106	80	133	1.8	-5.8	14.4
716-2A	2816	5.72	5.53	5.95	6128	5474	6906	109	101	121	3.1	-2.3	12.5
	2825	5.24	5.03	5.49	6368	5850	6992	117	105	136	0.3	-11.4	10.6
717-2A	2816	5.90	5.58	6.12	5744	3976	7423	89	18	145	3.4	-8.2	14.2
	2825	5.39	4.70	5.87	5838	3866	7720	93	18	170	2.4	-14.4	14.9
718-2A	2816	5.79	5.62	5.95	6565	6019	7441	111	101	132	3.6	-11.5	11.6
	2825												

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

RUN NO.	ANALYTICAL POINT	CA++			MG++			SO3=			SO4=			CL-		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
719-2A	2816	1130	1015	1260	415	369	519	166	79	260	2080	1933	2210	1524	1123	2127
	2825	1187	1012	1470	414	322	549	272	79	429	2177	1822	2380	1501	1196	1950
801-2A	2816	953	866	1080	372	277	448	109	45	237	2299	2133	2457	966	799	1462
	2825	1002	874	1106	368	306	435	319	79	678	2457	2149	2665	932	799	1119
801-2B	2816	987	930	1065	378	357	420	180	102	351	2133	1959	2400	1137	1063	1287
	2825	1150	1070	1260	361	307	392	595	362	1074	2326	2223	2446	1132	975	1287
802-2A	2816	1068	1010	1200	382	332	490	101	34	158	1987	1880	2285	1469	1321	1677
	2825	1153	1068	1255	382	321	486	331	204	452	2207	1805	2541	1454	1331	1598
803-2A	2816	1159	1030	1355	478	409	555	141	33	463	2164	1867	2665	1850	1750	1994
	2825	1252	1087	1470	477	413	561	510	180	1085	2267	1919	2522	1840	1684	2038
804-2A	2816	1344	920	1930	553	459	630	64	11	158	2079	1685	2467	2319	1573	3368
	2825	1469	1067	2190	556	423	639	351	79	678	2347	1760	2828	2353	1595	3722
805-2A	2816	1122	940	1470	539	372	639	188	11	474	2334	2078	2606	1581	1307	2087
	2825	1297	1017	1687	551	452	650	647	294	1062	2676	2182	3090	1574	1307	2127
	2831															
806-2A	2816	1340	1105	1565	519	439	610	433	192	701	2186	1966	2353	1961	1506	2393
	2825	1461	1175	1732	543	471	594	872	576	1153	2244	1984	2732	1905	1462	2393
	2831															
807-2A	2816	1282	957	1605	510	470	591	123	0	361	1948	1669	2452	2116	1506	2880
	2825	1479	1250	1900	496	340	560	462	11	1017	2327	1784	2974	2089	1462	2925
	2831															
808-2A	2816	1832	1570	2105	513	416	594	622	22	1967	2111	1689	2859	2922	2260	3456
	2825	2026	1740	2250	524	452	620	1104	316	2046	2263	1623	2797	2919	2260	3589
	2831															
809-2A	2816	1725	1400	1945	646	549	733	447	33	949	2194	1696	2692	2957	2659	3235
	2825	1921	1535	2165	631	499	754	970	350	1583	2427	1391	2891	2988	2792	3279
	2831															
810-2A	2816	1585	1395	1785	754	562	904	95	5	531	2283	2017	2614	3052	2747	3323
	2825	1780	1445	2195	750	629	882	567	248	1402	2531	1942	2958	3013	2792	3213
	2831															
811-2A	2816	966	777	1152	393	288	562	62	11	169	2166	1722	2778	1303	952	1861
	2825	1129	900	1325	392	254	452	427	101	893	2563	1783	3262	1268	842	1905
	2831															
812-2A	2816	1155	897	1387	406	335	499	155	33	723	2015	1763	2549	1712	1196	2348
	2825	1354	1085	1592	416	307	528	637	158	1605	2209	1068	2707	1694	1240	2260
	2831															
813-2A	2816	1085	927	1395	394	178	637	91	22	452	1807	1295	2026	1657	1063	2614
	2825	1229	1085	1577	351	201	439	530	316	1130	1898	634	2581	1495	1107	2082
	2831															
814-2A	2816	1226	1060	1352	411	372	517	432	180	904	2218	1792	2858	1655	1418	1950
	2825	1308	1125	1490	402	381	442	737	327	1187	2133	1678	2663	1635	1240	1905
	2831															
815-2A	2816	1227	1050	1470	458	395	529	126	90	158	2128	1962	2239	1564	1285	1950

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PH			TOTAL IONS, PPM			PERCENT GYPSUM SATURATION			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
719-2A	2816	5.76	5.54	6.04	5412	5002	6120	104	96	115	3.2	-14.7	14.5
	2825	5.24	5.02	5.49	5650	5088	6448	111	93	129	1.9	-14.4	11.7
801-2A	2816	5.87	5.63	5.97	4795	4517	5373	108	95	120	3.9	-12.8	12.9
	2825	5.21	4.89	5.66	5179	4790	5844	118	102	136	-2.5	-14.7	4.6
801-2B	2816	5.74	5.46	5.90	4908	4654	5335	103	98	114	2.8	-4.0	11.2
	2825	5.09	4.95	5.29	5657	5375	6327	121	116	127	-5.7	-11.6	-1.2
802-2A	2816	5.78	5.71	5.97	5098	4800	5685	100	94	107	2.6	-2.9	10.6
	2825	5.07	4.95	5.29	5623	4865	6263	114	94	134	-3.3	-10.9	6.9
803-2A	2816	5.05	4.71	5.29	5899	5501	6543	104	87	126	-0.1	-10.5	7.5
	2825	3.79	3.29	4.33	6455	5983	7039	113	93	129	-6.2	-12.0	4.1
804-2A	2816	5.06	4.85	5.33	6503	5377	7711	101	96	112	5.4	-6.5	13.7
	2825	3.86	3.29	4.65	7219	5816	8533	118	95	137	-0.8	-14.8	13.8
805-2A	2816	5.30	4.74	5.57	5931	5420	6909	104	90	124	7.6	0.7	11.3
	2825	4.59	4.03	4.98	6907	6323	7891	126	104	142	-0.6	-6.0	3.6
	2831												
806-2A	2816	5.35	5.25	5.49	6580	5650	7334	110	93	127	2.7	-8.9	13.4
	2825	4.82	4.70	4.92	7161	6343	8063	115	104	132	0.3	-7.6	7.7
	2831												
807-2A	2816	5.47	5.16	5.81	6137	5594	6857	97	90	114	7.1	-6.0	14.6
	2825	4.80	3.78	5.04	7010	6158	8044	123	101	149	0.8	-6.5	11.4
	2831												
808-2A	2816	5.11	4.91	5.27	8167	7729	8991	123	98	152	-1.9	-13.5	4.7
	2825	4.71	4.45	4.96	9005	8389	9819	135	106	161	-4.7	-14.1	5.8
	2831												
809-2A	2816	5.24	5.02	5.81	8173	7234	9448	116	94	144	4.2	-9.4	13.6
	2825	4.73	4.52	5.04	9141	8004	10408	134	85	166	-2.8	-13.2	14.8
	2831												
810-2A	2816	5.44	4.83	5.71	7975	7440	8474	109	93	127	8.1	-6.6	14.8
	2825	4.83	4.07	5.25	8851	8117	9433	127	99	161	3.4	-13.3	14.0
	2831												
811-2A	2816	5.83	5.60	6.06	5016	4591	5485	102	90	139	1.3	-10.0	12.2
	2825	5.16	4.86	5.69	5904	5380	6424	127	93	158	-7.7	-14.5	2.7
	2831												
812-2A	2816	5.57	5.33	5.87	5547	5029	7082	103	89	130	2.0	-7.5	9.8
	2825	5.09	4.86	5.67	6412	5312	7302	119	66	140	-3.5	-13.8	14.9
	2831												
813-2A	2816	5.34	5.19	5.45	5145	4063	6535	92	76	119	3.6	-13.8	11.6
	2825	4.59	4.24	4.73	5613	4285	6772	103	41	139	-0.7	-12.1	11.5
	2831												
814-2A	2816	5.36	5.16	5.75	6067	5307	6610	115	99	148	-4.2	-14.5	8.9
	2825	4.98	4.70	5.40	6334	5662	7200	115	100	138	-6.2	-14.3	6.4
	2831												
815-2A	2816	6.26	6.00	6.41	5608	5227	6203	107	99	116	10.4	2.5	13.9

RUN SUMMARY - LIQUID ANALYTICAL DATA

CONCENTRATIONS IN LIQUID, PPM

RUN NO.	ANALYTICAL POINT	CA++ AVG	CA++ MIN	CA++ MAX	MG++ AVG	MG++ MIN	MG++ MAX	SO3= AVG	SO3= MIN	SO3= MAX	SO4= AVG	SO4= MIN	SO4= MAX	CL- AVG	CL- MIN	CL- MAX
815-2A	2825	1254	1040	1530	439	389	524	222	135	395	2231	2128	2414	1442	1152	1950
816-2A	2816	1026	980	1120	415	379	472	90	11	158	2084	1902	2217	1233	1107	1373
	2825	1068	1035	1120	433	389	469	272	22	588	2133	1953	2307	1211	1063	1329
	2832															
817-2A	2816	1053	945	1260	406	367	441	155	67	350	2096	1909	2270	1311	1107	1506
	2825	1209	1090	1385	388	324	454	470	119	802	2311	1921	2719	1294	1152	1506
	2832															
818-2A	2816	1115	1035	1200	453	360	543	111	67	203	1994	1797	2141	1545	1373	1728
	2825	1150	1070	1290	437	363	490	211	101	361	2039	1810	2281	1491	1373	1684
	2832															
818-2B	2816	1180	1035	1475	464	403	612	112	56	180	2211	2015	2341	1556	1373	1772
	2825	1189	1050	1525	449	333	590	223	99	373	2164	2009	2336	1528	1373	1861
819-2A	2816	1300	1080	1530	379	326	430	329	11	1153	2055	1777	2728	1628	1376	1950
	2825	1433	1130	1725	380	324	425	669	45	1673	2195	1626	2866	1596	1331	1905
820-2A	2816	1411	1200	1725	369	320	617	260	22	915	2006	1550	2474	1808	1595	2969
	2825	1548	1335	1900	363	313	406	597	204	1277	2129	1585	2632	1772	1551	2171
821-2A	2816	640	488	874	5852	4820	6360	1496	90	2895	20731	17395	24153	2605	1819	3905
	2825	684	530	924	5928	4650	6470	2030	656	3573	20482	17099	24080	2615	1775	3861

RUN SUMMARY - LIQUID ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALY TICAL POINT	PH			TOTAL IONS, PPM			PERCENT GYPSUM SATURATION			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
815-2A	2825	5.33	5.19	5.46	5692	5317	6475	114	101	127	9.0	1.2	12.7
816-2A	2816	6.26	6.04	6.42	4947	4874	5095	100	91	107	9.1	2.5	14.4
	2825	5.36	5.16	5.61	5214	5054	5414	103	95	115	7.2	1.2	13.8
	2832												
817-2A	2816	5.84	5.79	5.89	5123	4807	5463	102	94	115	5.2	0.0	12.8
	2825	5.23	4.99	5.54	5775	5232	6363	120	109	135	-1.0	-9.8	8.8
	2832												
818-2A	2816	6.17	5.99	6.35	5323	4898	5643	97	83	105	8.8	3.1	12.2
	2825	5.43	5.25	5.61	5436	5160	5789	102	93	115	7.3	3.3	14.9
	2832												
818-2B	2816	6.14	5.50	6.40	5634	5296	6123	109	99	124	7.7	2.3	14.6
	2825	5.43	5.23	5.67	5658	5425	5851	108	95	134	5.8	-4.9	14.0
819-2A	2816	5.57	5.07	6.07	5794	5027	6744	113	97	131	2.5	-13.0	14.0
	2825	5.17	4.36	5.48	6380	5356	7624	124	85	159	-1.2	-11.2	14.7
820-2A	2816	5.68	5.29	6.06	5967	5100	7691	115	89	146	5.2	-5.5	13.8
	2825	5.33	5.00	5.60	6519	5647	7621	126	104	155	1.5	-14.7	14.8
821-2A	2816	5.34	5.10	5.90	31465	25298	33673	108	92	156	-4.8	-14.1	4.6
	2825	5.12	4.90	5.50	31881	25238	34807	113	91	158	-4.7	-10.4	2.9

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

RUN NO.	ANALYTICAL POINT	CO2			SO2			SO3			CAO			ACID INSOLUBLES WT % IN SLURRY			SOLIDS WT % IN SLURRY		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
TFG-2A	2816 2825	5.52	3.11	9.02	24.10	19.54	28.99	4.67	0.98	8.11	31.79	29.42	35.49	3.04	2.63	3.53	15.8	13.5	18.9
TFG-2B	2816 2825	7.91	1.74	14.55	20.53	14.69	27.65	4.38	0.65	8.84	31.93	24.66	37.29	4.09	3.47	4.76	15.4	14.4	16.7
TFG-2C	2816 2825	3.93	2.51	6.58	23.88	15.92	27.69	3.71	1.50	5.92	28.96	21.95	32.27	5.50	4.98	6.25	15.4	14.5	16.7
TFG-2D	2816 2825	3.83	2.80	6.49	23.95	19.54	26.42	3.67	0.19	5.72	29.33	26.30	31.17	3.88	3.72	3.99	14.0	12.8	19.5
TFG-2E	2816 2825	3.71	2.72	5.47	21.64	18.09	24.31	3.65	0.46	7.74	27.30	25.24	29.27	5.18	4.19	6.08	14.5	12.6	15.1
TFG-2F	2816 2825	3.93	2.82	4.78	23.14	19.54	29.31	5.60	2.26	10.18	29.72	25.56	33.20	4.37	3.37	5.37	15.1	12.9	16.2
525-2A	2816 2825	6.27	6.27	6.27	16.02	16.02	16.02	5.92	5.92	5.92	25.05	25.05	25.05				14.9	14.9	14.9
526-2A	2816 2825	6.62	2.58	11.17	14.56	11.02	17.87	7.15	4.48	11.28	25.21	19.73	30.85				14.7	13.8	15.9
527-2A	2816 2825	10.32	6.88	12.04	14.65	12.49	17.36	6.06	4.33	8.97	29.46	26.37	30.99				14.7	10.7	16.0
528-2A	2816 2825	4.74	2.42	6.88	19.18	15.70	22.36	5.63	2.37	8.91	26.14	23.96	28.60				14.8	10.7	16.6
529-2A	2816 2825	5.51	4.40	6.34	15.71	14.67	16.72	6.98	4.81	8.28	24.20	23.47	25.80				15.1	14.5	15.5
530-2A	2816 2825	6.79	3.90	10.75	17.91	13.20	21.20	5.65	3.23	8.48	27.05	23.99	30.33				14.8	12.8	16.0
531-2A	2816 2825	5.94	1.01	13.41	16.81	10.91	22.23	6.65	2.79	13.59	28.30	17.49	35.50				8.1	7.1	10.0
532-2A	2816 2825	5.41	2.71	9.22	17.95	15.70	21.52	5.44	3.29	7.47	27.64	24.21	31.40				8.7	7.8	9.9
533-2A	2816 2825	6.26	2.88	9.33	20.11	12.89	24.62	5.61	1.77	8.52	30.12	25.54	32.36				14.8	12.2	17.6
534-2A	2816 2825	4.40	1.42	6.06	20.65	19.40	22.00	6.33	3.55	11.39	27.29	25.70	29.50	5.13	4.20	6.42	12.0	10.1	14.6
535-2A	2816 2825	7.68	3.76	11.60	18.78	13.20	23.96	4.73	1.10	9.82	29.32	25.40	32.87	5.18	3.38	7.10	13.5	9.0	16.7
535-2B	2816 2825	4.97	1.30	7.40	19.75	14.60	24.20	5.41	2.34	9.16	26.87	23.91	30.54	5.10	4.00	6.58	12.3	8.9	15.0
536-2A	2816 2825	5.87	1.61	9.11	18.51	14.50	21.90	5.22	1.54	9.53	26.78	23.57	28.85	5.88	4.62	7.00	13.8	11.2	16.4
537-2A	2816 2825	5.85	2.61	8.55	18.24	12.50	21.91	4.36	3.18	8.90	27.13	24.72	29.87	6.05	5.00	7.35	13.9	12.7	16.8
538-2A	2816 2825	8.03	5.09	12.30	18.29	13.40	22.30	5.02	1.95	9.36	29.21	26.06	33.96	5.73	3.01	6.81	15.1	12.5	17.1
539-2A	2816	10.39	6.09	13.91	19.17	15.30	23.90	3.94	0.70	7.66	31.59	28.38	34.42	4.87	4.16	6.22	14.3	12.7	16.7

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PERCENT SULFITE OXIDATION AVG	PERCENT SULFITE OXIDATION MIN	PERCENT SULFITE OXIDATION MAX	STOICHIOMETRIC RATIO AVG	STOICHIOMETRIC RATIO MIN	STOICHIOMETRIC RATIO MAX	PERCENT IONIC IMBALANCE AVG	PERCENT IONIC IMBALANCE MIN	PERCENT IONIC IMBALANCE MAX
TFG-2A	2816 2825	13.2	3.4	22.0	1.31	1.15	1.59	1.2	-4.4	5.0
TFG-2B	2816 2825	14.2	3.0	25.5	1.56	1.08	2.20	2.5	-2.9	8.3
TFG-2C	2816 2825	11.1	4.2	16.4	1.22	1.12	1.50	1.3	-8.5	7.3
TFG-2D	2816 2825	10.9	0.7	19.0	1.21	1.14	1.37	3.1	-1.7	6.4
TFG-2E	2816 2825	11.8	1.7	24.6	1.22	1.15	1.31	4.0	-1.3	7.5
TFG-2F	2816 2825	16.2	7.9	27.9	1.21	1.15	1.25	1.8	-3.2	8.2
525-2A	2816 2825	22.8	22.8	22.8	1.44	1.44	1.44	-4.4	-4.4	-4.4
526-2A	2816 2825	28.2	17.3	44.3	1.48	1.19	1.87	-3.7	-7.9	4.5
527-2A	2816 2825	24.8	19.0	36.5	1.78	1.45	1.96	-2.6	-6.7	3.7
528-2A	2816 2825	19.1	8.3	26.3	1.30	1.14	1.49	-2.4	-8.4	6.8
529-2A	2816 2825	26.2	18.7	30.2	1.38	1.29	1.44	-6.1	-8.2	-4.7
530-2A	2816 2825	20.3	11.6	34.0	1.45	1.23	1.72	-4.6	-8.4	5.3
531-2A	2816 2825	24.2	12.0	48.8	1.41	1.06	2.25	4.7	-7.7	8.5
532-2A	2816 2825	19.5	13.2	25.9	1.36	1.17	1.69	4.5	-1.9	8.4
533-2A	2816 2825	18.4	6.4	32.1	1.38	1.17	1.63	2.1	-5.7	7.5
534-2A	2816 2825	19.3	12.2	31.1	1.25	1.07	1.35	-3.0	-7.1	-0.6
535-2A	2816 2825	16.9	3.7	32.8	1.50	1.21	1.83	-0.8	-8.4	8.5
535-2B	2816 2825	18.1	7.9	28.8	1.31	1.07	1.45	-2.1	-8.4	8.4
536-2A	2816 2825	18.4	6.6	33.1	1.38	1.09	1.69	-2.1	-8.0	6.4
537-2A	2816 2825	16.3	10.4	36.3	1.40	1.16	1.59	2.4	-1.5	7.0
538-2A	2816 2825	18.2	7.0	35.0	1.53	1.33	1.89	-2.0	-8.2	6.8
539-2A	2816	14.3	2.8	28.6	1.70	1.33	2.08	-3.9	-8.1	5.6

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

RUN NO.	ANALYTICAL POINT	CO2			SO2			SO3			CAO			ACID INSOLUBLES WT % IN SLURRY			SOLIDS WT % IN SLURRY		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
539-2A	2825																		
540-2A	2816	9.63	5.34	13.47	20.56	17.90	22.40	3.45	0.56	6.15	30.96	27.60	33.73	4.76	4.17	5.48	14.2	13.3	14.9
	2825																		
541-2A	2816	10.94	9.85	12.25	17.73	16.20	19.70	5.68	5.34	5.99	32.88	31.09	34.03	4.52	3.68	5.75	14.8	13.9	16.5
	2825																		
542-2A	2816	8.64	5.65	10.21	17.98	15.30	22.70	4.58	3.33	5.21	29.80	28.60	30.84	5.56	5.04	6.10	14.7	13.7	15.8
	2825																		
543-2A	2816	6.73	6.02	7.27	19.23	19.00	19.50	5.53	4.37	6.61	28.40	27.97	29.03	5.03	4.94	5.14	13.1	12.9	13.5
	2825																		
544-2A	2816	7.89	4.90	11.72	18.04	14.20	20.70	5.34	3.00	7.53	29.37	27.16	32.84	4.89	1.51	6.07	15.4	12.3	40.4
	2825																		
545-2A	2816	7.11	4.29	10.90	19.57	14.70	22.80	5.14	3.07	8.81	29.40	27.35	32.34	5.10	4.04	5.72	13.6	13.0	14.7
	2825																		
546-2A	2816	4.98	2.05	9.55	20.84	17.50	23.20	5.05	3.98	6.01	27.15	23.44	32.44	6.03	4.70	7.67	15.0	11.5	16.3
	2825																		
547-2A	2816	7.15	5.34	8.48	22.88	21.10	24.70	3.10	2.27	4.30	30.13	28.48	30.90	5.31	4.72	5.84	14.9	13.7	15.9
	2825																		
548-2A	2816	9.38	6.89	11.49	19.75	18.40	21.10	3.34	2.67	4.30	31.04	28.65	33.89	4.53	3.69	5.27	12.8	11.4	14.5
	2825																		
549-2A	2816	7.63	6.43	8.90	19.26	18.20	21.40	3.35	2.03	4.95	29.96	29.14	33.51	5.80	4.77	6.73	14.6	12.8	15.7
	2825																		
550-2A	2816	8.39	7.53	9.60	19.67	16.40	23.00	4.52	2.37	9.11	31.36	28.71	33.06	5.09	3.26	5.74	14.7	12.5	15.7
	2825																		
551-2A	2816	8.75	7.80	9.44	22.05	20.20	24.80	2.69	1.80	3.45	32.69	30.15	34.32	4.75	4.58	4.90	14.4	14.0	14.8
	2825																		
552-2A	2816	7.29	5.90	9.24	22.09	18.40	25.20	3.40	0.53	6.37	31.04	29.36	32.91	5.36	4.92	5.76	15.2	14.6	15.7
	2825																		
553-2A	2816	7.27	5.86	8.53	16.30	13.30	17.90	5.36	4.47	6.17	28.15	25.28	29.80	6.75	5.57	7.92	15.1	14.2	16.0
	2825																		
554-2A	2816	8.74	7.50	9.80	17.42	15.60	18.30	4.10	0.73	8.20	29.00	26.40	30.50				15.1	14.9	15.3
	2825																		
555-2A	2816	8.97	8.77	9.31	16.83	15.80	17.90	3.56	3.26	3.83	29.70	29.60	29.84	5.99	5.86	6.20	14.6	13.9	15.0
	2825																		
556-2A	2816	8.77	5.00	12.50	15.80	13.60	17.20	5.66	3.13	9.30	28.31	25.47	31.40	5.34	4.58	5.90	12.8	10.8	14.5
	2825																		
557-2A	2816	5.90	2.89	11.23	19.85	14.80	23.90	4.00	2.00	6.59	26.94	22.66	30.80	6.22	5.47	7.11	14.9	13.5	16.2
	2825																		
558-2A	2816	5.39	2.07	9.08	19.41	14.20	23.30	4.28	2.36	7.76	26.71	20.44	30.52	6.34	5.47	7.79	14.5	11.3	16.5
	2825																		
559-2A	2816	6.32	2.23	8.89	19.90	15.00	25.20	4.02	1.63	7.87	28.13	23.92	30.09	6.15	5.40	6.85	15.0	13.1	16.3
	2825																		
560-2A	2816	7.65	4.99	10.78	20.35	16.00	23.20	3.40	2.16	4.39	30.07	28.02	32.74	5.93	3.45	7.19	14.8	9.4	16.4
	2825																		

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PERCENT SULFITE OXIDATION			STOICHIOMETRIC RATIO			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
539-2A	2825									
540-2A	2816 2825	11.8	2.0	21.6	1.61	1.31	1.92	-5.6	-8.5	-2.3
541-2A	2816 2825	20.5	19.6	22.0	1.72	1.64	1.86	-1.7	-3.1	-0.8
542-2A	2816 2825	17.4	10.5	21.4	1.60	1.32	1.76	-0.6	-2.8	0.9
543-2A	2816 2825	18.6	15.6	21.3	1.41	1.35	1.47	-3.2	-5.0	0.2
544-2A	2816 2825	19.2	11.8	27.6	1.53	1.28	1.94	-0.8	-6.3	5.9
545-2A	2816 2825	17.5	10.1	32.4	1.45	1.24	1.73	-1.4	-6.2	2.5
546-2A	2816 2825	16.3	12.0	20.8	1.29	1.13	1.61	-3.6	-7.9	2.5
547-2A	2816 2825	9.8	7.5	12.9	1.41	1.28	1.50	-4.0	-8.5	1.8
548-2A	2816 2825	11.9	10.2	14.1	1.62	1.42	1.80	-1.9	-8.3	2.7
549-2A	2816 2825	12.2	7.5	17.9	1.51	1.43	1.58	3.4	-4.9	8.1
550-2A	2816 2825	15.5	7.6	28.4	1.53	1.44	1.67	0.8	-3.2	6.7
551-2A	2816 2825	9.0	5.5	12.0	1.53	1.43	1.59	0.8	-7.8	5.7
552-2A	2816 2825	11.0	1.6	21.7	1.43	1.33	1.57		-5.0	5.9
553-2A	2816 2825	21.1	16.8	27.1	1.51	1.47	1.58	3.3	-0.4	7.3
554-2A	2816 2825	15.5	3.2	29.6	1.62	1.49	1.70	-0.9	-4.9	2.2
555-2A	2816 2825	14.5	12.7	16.3	1.66	1.65	1.68	3.5	0.1	6.4
556-2A	2816 2825	22.1	13.3	35.4	1.63	1.36	1.90	-2.3	-8.4	6.3
557-2A	2816 2825	14.2	7.3	23.4	1.38	1.17	1.76	-2.6	-8.0	8.4
558-2A	2816 2825	15.2	8.2	29.6	1.35	1.12	1.63	-0.7	-7.8	7.7
559-2A	2816 2825	14.0	5.3	25.9	1.40	1.12	1.65	-0.6	-7.5	8.4
560-2A	2816 2825	11.9	7.6	15.4	1.49	1.31	1.83	0.4	-6.8	7.4

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

RUN NO.	ANALYTICAL POINT	CO2			SO2			SO3			CAO			ACID INSOLUBLES WT % IN SLURRY			SOLIDS WT % IN SLURRY		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
561-2A	2816 2825	6.47	3.98	9.09	22.36	19.70	25.00	2.98	1.77	5.80	29.09	27.69	31.67	5.77	5.48	6.28	14.7	14.1	15.7
562-2A	2816 2825	9.15	4.99	15.24	20.18	12.60	25.10	3.56	1.10	9.08	31.95	27.82	38.80	5.13	3.25	7.20	15.1	11.1	17.5
562-2B	2816 2825	7.57	5.14	10.55	19.05	13.10	23.50	5.25	2.33	7.84	29.44	27.94	33.32	5.46	4.65	6.17	14.8	14.1	16.2
563-2A	2816 2825	11.21	7.95	14.11	20.66	17.40	23.90	1.79	-0.67	4.59	34.63	31.15	37.43	4.77	4.02	5.50	15.1	13.3	15.8
564-2A	2816 2825	0.87	0.33	1.49	21.36	19.40	25.80	6.08	5.18	6.98	22.75	20.49	27.70	6.71	5.55	7.48	13.9	12.1	15.0
565-2A	2816 2825	0.91	0.66	1.16	20.93	17.60	24.30	4.69	2.52	8.64	21.62	20.45	24.22	7.44	6.94	7.81	14.4	14.0	15.1
566-2A	2816 2825	4.62	0.66	9.78	22.77	18.80	26.50	3.37	0.98	7.92	26.97	20.79	32.66	6.22	4.62	7.74	15.0	13.8	15.7
567-2A	2816 2825	7.58	4.41	9.57	21.62	16.90	24.90	3.45	2.06	6.78	29.10	26.47	30.40	5.67	5.23	6.10	15.2	14.3	15.8
568-2A	2816 2825	1.11	0.44	1.72	23.54	16.24	26.80	5.28	1.96	9.16	24.90	22.75	29.50	7.02	5.89	7.71	15.0	14.0	15.8
569-2A	2816 2825	1.43	0.78	1.79	20.03	18.10	22.90	5.93	5.18	7.13	23.10	21.45	24.40	7.25	7.23	7.27	14.5	14.2	14.9
569-2B	2816 2825	1.36	0.65	1.85	21.06	17.60	24.00	5.03	3.26	7.17	22.80	21.23	25.00	7.43	6.60	8.07	15.0	14.0	16.1
570-2A	2816 2825	2.94	1.82	4.95	20.73	18.20	23.70	4.87	2.34	8.98	24.26	22.52	28.30	6.91	5.70	7.87	14.8	13.3	15.7
571-2A	2816 2825	3.99	1.96	5.67	18.95	15.90	23.00	3.95	1.46	6.08	24.04	22.46	25.74	7.41	6.77	8.42	15.0	14.0	15.9
571-2B	2816 2825	5.28	1.22	7.61	19.70	18.70	20.20	5.37	3.17	6.86	27.64	22.28	31.58	5.53	4.75	6.05	13.7	12.7	14.7
572-2A	2816 2825	1.39	0.23	2.09	18.38	13.70	21.40	5.37	2.60	7.56	21.78	19.61	24.30	7.81	6.67	8.88	14.4	12.9	15.8
573-2A	2816 2825	1.37	1.02	2.20	19.58	16.24	24.45	5.85	2.63	9.16	22.41	21.75	23.05	7.39	6.62	7.97	14.8	13.6	15.8
575-2A	2816 2825	2.96	2.69	3.43	21.53	20.30	22.80	3.63	3.06	4.20	23.53	22.43	24.63	7.21	6.05	7.73	14.8	13.6	15.8
576-2A	2816 2825	3.37	2.07	6.16	21.31	16.90	23.20	4.14	1.08	9.64	24.44	22.52	28.20	7.02	5.54	7.86	15.1	14.2	15.8
576-2B	2816 2825	2.69	1.10	4.07	20.42	18.00	21.80	5.12	3.65	6.82	23.93	23.40	24.70	6.85	6.85	6.85	15.0	15.0	15.0
577-2A	2816 2825	4.43	1.87	5.88	22.55	17.70	25.40	3.63	1.44	6.05	27.02	21.22	32.00	6.32	4.94	8.54	15.1	13.5	16.0
578-2A	2816 2825	6.34	3.83	8.08	22.90	21.70	25.00	2.58	0.85	3.66	28.93	27.10	31.40						
579-2A	2816	0.96	0.66	1.38	21.11	16.70	25.00	6.22	4.05	8.63	23.65	21.30	26.10	7.12	6.33	7.93	15.0	14.0	16.3

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PERCENT SULFITE OXIDATION AVG	MIN	MAX	STOICHIOMETRIC RATIO AVG	MIN	MAX	PERCENT IONIC IMBALANCE AVG	MIN	MAX
561-2A	2816 2825	9.7	5.5	17.7	1.39	1.23	1.59	-2.8	-7.8	6.1
562-2A	2816 2825	12.5	4.5	35.5	1.59	1.27	2.14	0.2	-8.5	8.4
562-2B	2816 2825	18.3	8.0	32.4	1.48	1.28	1.78	-2.0	-8.5	6.5
563-2A	2816 2825	6.5	-2.6	15.4	1.75	1.47	2.02	2.8	-6.2	8.4
564-2A	2816 2825	18.6	17.0	22.2	1.05	1.02	1.09	-5.9	-8.0	-4.0
565-2A	2816 2825	15.3	7.7	28.2	1.05	1.04	1.06	-5.5	-7.7	-1.2
566-2A	2816 2825	10.6	3.0	22.9	1.27	1.04	1.62	-4.6	-7.7	-0.1
567-2A	2816 2825	11.4	6.2	21.7	1.46	1.25	1.65	-6.5	-8.5	-1.7
568-2A	2816 2825	15.3	5.8	31.1	1.06	1.02	1.09	-3.4	-8.5	3.1
569-2A	2816 2825	19.3	15.3	24.0	1.09	1.04	1.11	-1.9	-7.1	3.3
569-2B	2816 2825	16.1	10.2	24.6	1.08	1.04	1.12	-3.9	-8.1	4.4
570-2A	2816 2825	15.9	7.7	27.5	1.17	1.10	1.33	-4.4	-8.5	3.5
571-2A	2816 2825	14.5	5.3	23.4	1.27	1.12	1.40	-1.7	-8.1	5.9
571-2B	2816 2825	17.7	11.4	21.4	1.33	1.07	1.50	-1.1	-7.9	7.4
572-2A	2816 2825	19.1	9.4	30.6	1.09	1.01	1.15	0.7	-8.4	8.0
573-2A	2816 2825	19.6	7.9	31.1	1.08	1.06	1.14	-2.6	-8.1	7.0
575-2A	2816 2825	11.9	9.9	13.8	1.18	1.16	1.21	-6.9	-8.5	-6.0
576-2A	2816 2825	13.4	3.6	28.0	1.20	1.11	1.42	-5.8	-8.3	2.9
576-2B	2816 2825	16.8	11.8	22.7	1.16	1.06	1.25	-4.0	-6.4	-2.1
577-2A	2816 2825	11.5	4.8	20.2	1.25	1.11	1.34	-3.5	-8.5	7.1
578-2A	2816 2825	8.2	2.9	11.4	1.38	1.20	1.48	-3.8	-8.2	2.3
579-2A	2816	19.1	12.9	29.2	1.05	1.03	1.09	-1.7	-3.6	0.5

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

RUN NO.	ANALYTICAL POINT	CO2			SO2			SO3			CAO			ACID INSOLUBLES WT % IN SLURRY			SOLIDS WT % IN SLURRY		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
579-2A	2825																		
580-2A	2816 2825	2.57	0.61	4.57	20.00	18.20	21.90	5.07	4.35	6.13	24.18	22.60	25.80	7.37	7.37	7.37	15.4	15.4	15.4
581-2A	2816 2825	3.02	0.81	6.23	19.81	15.60	24.80	9.03	3.33	14.80	27.08	21.60	31.20	5.94	4.72	8.09	15.2	13.9	20.4
582-2A	2816 2825	7.67	1.54	13.81	18.87	14.70	21.50	10.19	8.38	13.18	32.49	27.70	38.80	4.11	3.83	4.39	16.1	15.2	17.0
583-2A	2816 2825	3.93	1.18	6.32	18.21	13.80	22.60	9.98	6.95	14.80	28.48	25.55	30.80	5.46	3.89	6.34	14.7	13.2	16.6
583-2B	2816 2825	5.33	2.07	10.17	16.62	10.90	22.80	10.23	6.95	15.33	28.78	25.10	34.20	5.37	2.73	7.57	14.8	7.7	17.7
584-2A	2816 2825	7.46	2.39	13.44	20.60	14.50	27.40	5.51	0.83	9.88	31.86	28.00	34.70	5.38	4.30	7.68	15.4	13.0	17.9
585-2A	2816 2825	7.27	4.41	9.54	17.71	13.80	21.30	7.53	3.18	11.43	30.47	27.90	33.40	5.23	4.13	6.52	14.8	13.1	16.3
586-2A	2816 2825	6.39	5.17	9.79	18.58	14.50	21.30	7.42	0.98	11.80	29.61	24.50	31.70	5.38	3.83	7.15	14.5	12.6	15.8
587-2A	2816 2825	8.20	5.12	12.29	16.44	12.10	21.10	7.19	3.08	12.68	30.29	25.60	33.80	3.40	2.29	5.13	9.2	6.9	12.7
588-2A	2816 2825	11.75	8.83	15.40	11.50	7.20	15.30	6.47	4.10	9.55	30.99	29.00	34.80	5.28	4.64	5.78	14.2	12.9	15.1
589-2A	2816 2825	6.19	2.33	14.59	19.03	12.30	26.50	5.54	1.38	8.50	29.10	25.80	37.20	5.93	4.22	7.67	14.9	13.4	16.8
590-2A	2816 2825	1.55	1.19	1.98	10.09	9.04	11.58	9.95	7.99	12.63	17.78	17.32	18.32	6.86	6.56	7.12	13.8	13.2	14.5
590-2B	2816 2825	2.58	1.24	4.51	14.58	12.55	17.01	8.32	7.05	11.67	22.03	19.25	23.89	5.59	4.73	6.86	14.5	13.5	15.9
591-2A	2816 2825	4.40	2.29	7.92	12.35	4.47	18.42	11.65	6.99	20.30	24.02	18.74	27.77	5.33	4.20	6.21	14.4	13.1	15.9
592-2A	2816 2825	7.50	4.45	10.69	16.31	12.90	23.88	6.56	0.01	12.75	27.53	24.20	30.92	5.43	4.52	7.19	15.1	14.0	17.0
593-2A	2816 2825	9.72	5.20	13.30	14.92	11.10	20.20	6.15	3.25	8.33	28.92	22.10	31.90	5.14	4.30	6.40	15.0	13.2	17.8
594-2A	2816 2825	5.58	3.90	6.60	19.07	14.80	22.80	5.31	3.20	7.68	26.60	23.70	29.60	5.59	5.20	6.70	15.1	13.9	16.2
601-2A	2816 2825	0.76	0.16	1.08	22.87	20.00	26.80	5.70	2.38	9.78	25.85	20.70	30.80	3.75	2.72	4.71	8.3	7.3	9.0
602-2A	2816 2825	0.73	0.29	1.48	24.45	21.30	27.20	4.78	0.02	9.65	25.91	23.30	28.30	6.67	3.24	8.18	14.7	8.7	16.3
603-2A	2816 2825	0.55	0.05	3.82	21.44	17.90	24.40	6.24	2.68	10.95	23.84	18.60	26.90	3.88	3.17	5.13	8.1	7.2	9.3
604-2A	2816 2825	0.30	0.05	1.10	18.59	15.20	21.30	10.00	6.98	13.83	24.22	21.50	26.71	3.43	2.58	4.15	7.7	7.1	8.3

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

RUN	ANALY TICAL	PERCENT SULFITE OXIDATION			STOICHIOMETRIC RATIO			PERCENT IONIC IMBALANCE		
NO.	POINT	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
579-2A	2825									
580-2A	2816 2825	16.9	14.2	20.1	1.16	1.03	1.31	-0.7	-3.6	1.4
581-2A	2816 2825	26.6	10.4	41.2	1.17	1.04	1.39	-1.8	-7.7	6.8
582-2A	2816 2825	30.3	24.6	36.2	1.43	1.07	1.85	-3.1	-8.3	5.1
583-2A	2816 2825	30.6	20.9	41.2	1.22	1.06	1.39	2.0	-3.9	7.2
583-2B	2816 2825	32.8	26.0	43.5	1.32	1.14	1.70	0.4	-8.3	8.5
584-2A	2816 2825	17.4	3.2	28.7	1.46	1.13	2.09	1.5	-7.4	7.4
585-2A	2816 2825	25.4	13.1	35.4	1.45	1.24	1.60	1.5	-3.5	7.1
586-2A	2816 2825	23.0	5.1	35.1	1.40	1.29	1.93	0.1	-4.3	7.7
587-2A	2816 2825	25.5	14.7	45.6	1.56	1.30	1.99	1.3	-7.0	8.5
588-2A	2816 2825	31.2	22.7	47.4	2.07	1.68	2.53	4.5	-1.4	8.5
589-2A	2816 2825	18.8	5.3	34.9	1.42	1.12	2.12	2.2	-3.0	7.9
590-2A	2816 2825	43.9	35.6	52.8	1.13	1.09	1.17	-0.1	-0.8	0.4
590-2B	2816 2825	31.3	24.9	37.8	1.18	1.09	1.35	0.6	-4.6	7.4
591-2A	2816 2825	43.8	25.3	75.2	1.30	1.18	1.61	-2.8	-6.6	2.7
592-2A	2816 2825	23.1	0.0	44.0	1.55	1.24	2.16	-3.8	-7.9	3.5
593-2A	2816 2825	25.2	13.9	37.5	1.74	1.39	2.16	-2.9	-8.4	7.8
594-2A	2816 2825	18.4	11.0	25.8	1.35	1.23	1.46	-3.6	-7.9	5.1
601-2A	2816 2825	16.3	7.8	25.1	1.04	1.01	1.10	2.5	-7.9	7.2
602-2A	2816 2825	13.1	0.1	24.8	1.04	1.01	1.08	1.0	-6.3	8.2
603-2A	2816 2825	18.6	9.5	31.0	1.03	1.00	1.25	-0.9	-8.3	8.3
604-2A	2816 2825	30.0	20.8	37.3	1.02	1.00	1.06	2.3	-7.3	8.1

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

RUN NO.	ANALYTICAL POINT	CO2			SO2			SO3			CAO			ACID INSOLUBLES WT % IN SLURRY			SOLIDS WT % IN SLURRY		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
605-2A	2816 2825	0.56	0.19	0.93	24.49	19.72	28.23	7.36	4.64	11.62	27.61	23.26	30.80	2.15	1.37	2.89	7.8	7.0	8.8
606-2A	2816 2825	0.91	0.33	2.27	20.47	16.75	25.33	7.78	3.20	17.35	24.11	20.33	31.57	2.66	2.23	3.42	8.0	7.4	9.3
607-2A	2816 2825	0.87	0.13	1.58	22.85	18.08	26.24	5.23	0.04	13.84	25.48	21.95	29.73	2.70	2.06	3.88	7.8	6.9	8.6
608-2A	2816 2825	1.17	0.82	1.55	24.61	20.81	28.84	7.33	5.23	10.01	27.80	25.24	29.86	4.36	3.99	4.59	14.7	13.4	15.7
608-2B	2816 2825	1.44	1.02	1.84	26.01	21.17	28.67	4.70	2.22	9.39	27.79	25.73	30.14	4.51	4.05	5.08	14.8	14.0	15.6
609-2A	2816 2825	0.46	0.13	0.94	23.17	18.27	28.76	4.83	0.37	9.06	24.51	19.49	30.63	2.95	2.24	3.83	8.0	7.1	8.7
610-2A	2816 2825	0.74	0.35	1.08	22.79	17.96	28.95	2.64	0.25	5.51	23.63	19.19	28.55	2.58	1.84	2.95	7.9	7.2	8.7
611-2A	2816 2825	0.68	0.16	1.54	17.32	13.46	21.89	9.68	0.64	20.73	23.57	20.44	27.70	2.63	2.33	3.03	8.0	6.9	8.9
612-2A	2816 2825	0.33	0.11	0.66	18.04	15.53	20.26	9.99	7.08	12.33	24.54	21.00	27.10	2.75	2.32	3.31	8.0	7.0	9.2
613-2A	2816 2825	0.47	0.16	0.78	17.94	14.31	25.35	10.12	1.71	17.23	24.22	19.72	28.36	2.43	1.87	3.20	8.1	6.9	8.7
614-2A	2816 2825	0.83	0.22	2.00	22.06	19.00	25.41	3.56	0.80	5.98	24.37	21.98	27.62	2.76	2.42	3.55	7.9	4.0	9.1
615-2A	2816 2825	0.55	0.15	1.65	19.49	15.56	24.22	5.22	1.57	8.78	21.97	18.54	25.29	3.03	2.48	3.42	8.1	7.5	8.8
616-2A	2816 2825	1.24	0.33	2.97	20.91	15.45	24.56	6.52	0.90	13.91	24.54	17.61	30.74	2.99	2.46	3.36	7.9	4.9	8.8
617-2A	2816 2825	1.16	0.71	1.70	22.59	19.18	25.46	3.50	1.68	6.78	24.95	22.62	27.79	5.10	3.11	6.01	14.3	8.1	15.5
618-2A	2816 2825	1.18	0.77	2.07	16.84	13.66	22.19	7.89	4.99	11.25	21.97	19.70	25.07	3.00	2.33	3.87	7.9	6.5	10.0
618-2B	2816 2825	0.96	0.44	1.42	16.06	12.25	20.52	8.56	4.46	11.04	22.00	18.80	25.95	2.76	1.82	3.79	7.5	6.3	8.7
619-2A	2816 2825	0.78	0.27	1.98	20.12	14.96	25.33	7.43	2.73	14.34	24.48	19.02	29.31	2.72	1.76	4.07	8.0	6.9	9.5
620-2A	2816 2825	0.88	0.38	1.31	19.00	14.69	21.71	9.21	7.68	10.96	25.39	22.83	27.28	2.52	1.87	3.14	8.5	6.2	10.1
621-2A	2816 2825	0.82	0.10	4.16	17.21	12.30	20.50	8.47	6.00	11.16	22.26	18.81	27.98	3.29	1.88	4.21	8.1	6.3	9.2
622-2A	2816 2825	1.36	0.90	2.30	21.04	16.00	25.30	7.45	4.85	11.55	24.91	21.90	27.80	3.14	2.80	3.60	8.6	7.7	10.1
622-2B	2816 2825	0.99	0.10	2.50	19.42	15.00	21.30	3.81	1.35	5.50	21.40	16.50	24.20	3.56	2.90	5.30	8.0	7.3	9.2
623-2A	2816	1.32	0.10	5.10	22.51	18.40	28.60	4.38	1.00	8.20	23.93	19.90	26.90	3.21	2.50	4.20	8.2	7.4	9.3

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PERCENT SULFITE OXIDATION			STOICHIOMETRIC RATIO			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
605-2A	2816 2825	19.3	13.2	27.7	1.03	1.01	1.04	1.0	-7.7	7.2
606-2A	2816 2825	23.0	9.2	40.8	1.05	1.02	1.12	-1.8	-8.4	7.2
607-2A	2816 2825	15.1	0.1	31.8	1.05	1.01	1.09	2.8	-6.7	8.5
608-2A	2816 2825	19.3	12.7	26.2	1.06	1.04	1.07	-1.3	-5.6	1.6
608-2B	2816 2825	12.6	6.5	23.1	1.07	1.05	1.09	-0.4	-4.3	4.1
609-2A	2816 2825	14.1	1.1	26.0	1.03	1.01	1.05	1.0	-6.2	8.0
610-2A	2816 2825	8.5	0.9	19.6	1.05	1.02	1.07	3.8	-3.9	8.2
611-2A	2816 2825	29.8	2.5	54.1	1.04	1.01	1.10	3.4	-4.6	8.5
612-2A	2816 2825	30.6	25.0	37.9	1.02	1.01	1.04	5.4	2.5	8.4
613-2A	2816 2825	30.5	6.5	43.7	1.03	1.01	1.05	3.5	-0.6	8.0
614-2A	2816 2825	11.4	2.6	18.2	1.05	1.01	1.10	6.2	0.0	8.5
615-2A	2816 2825	17.7	5.3	27.6	1.03	1.01	1.09	2.6	-7.6	6.5
616-2A	2816 2825	18.6	4.3	33.8	1.07	1.01	1.17	0.4	-7.3	8.1
617-2A	2816 2825	11.0	5.6	22.0	1.07	1.04	1.11	5.0	0.0	8.4
618-2A	2816 2825	27.5	15.2	39.7	1.08	1.05	1.15	0.8	-4.9	7.3
618-2B	2816 2825	30.1	15.5	38.8	1.06	1.03	1.08	3.1	-4.7	8.5
619-2A	2816 2825	22.7	8.4	42.7	1.05	1.01	1.12	2.6	-5.8	7.7
620-2A	2816 2825	28.2	22.1	37.0	1.05	1.02	1.07	4.7	0.9	6.3
621-2A	2816 2825	28.3	20.0	41.3	1.05	1.01	1.26	0.8	-7.1	8.0
622-2A	2816 2825	22.3	13.8	35.8	1.08	1.04	1.15	-1.8	-6.2	4.5
622-2B	2816 2825	13.6	4.9	18.7	1.06	1.01	1.16	2.0	-7.3	8.4
623-2A	2816	13.5	3.5	25.1	1.08	1.01	1.31	-2.2	-7.8	4.6

RUN SUMMARY - SOLIDS ANALYTICAL DATA

• CONCENTRATIONS IN SOLIDS, WT %

RUN NO.	ANALYTICAL POINT	CO2			SO2			SO3			CAO			ACID INSOLUBLES WT % IN SLURRY			SOLIDS WT % IN SLURRY		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
623-2A	2825																		
624-2A	2816	0.84	0.30	1.30	20.69	17.90	24.90	4.39	-0.70	8.28	22.34	19.90	25.50	3.45	2.80	4.20	8.0	7.0	9.2
	2825																		
625-2A	2816	2.43	1.20	5.40	20.73	12.90	25.70	4.79	1.55	12.85	25.03	15.80	31.00	2.99	1.50	4.50	8.1	5.3	10.5
	2825																		
701-2A	2816	5.59	3.30	10.06	34.28	21.53	37.80	5.92	0.51	23.26	42.44	38.37	45.98	0.26	0.06	0.48	8.0	7.2	8.7
	2825																		
702-2A	2816	4.15	1.92	6.93	37.10	31.29	41.21	3.26	0.05	11.11	40.30	37.96	42.56	0.38	0.29	0.50	14.9	9.9	16.3
	2825																		
703-2A	2816	3.35	1.37	4.83	37.91	33.29	40.90	3.21	0.27	8.88	40.04	37.27	41.80	0.18	0.12	0.28	7.9	7.5	10.8
	2825																		
704-2A	2816	2.92	0.71	14.08	36.29	10.13	42.34	7.36	0.41	23.93	42.03	37.31	44.78	0.23	0.12	0.49	8.0	5.8	8.9
	2825																		
705-2A	2816	2.92	0.93	5.28	36.21	23.52	40.36	6.87	0.93	22.84	41.42	36.68	47.01	0.62	0.20	1.07	14.7	9.6	15.9
	2825																		
706-2A	2816	3.67	1.26	7.93	33.33	27.14	36.91	9.81	1.44	19.60	40.53	35.44	44.59	1.09	0.19	7.05	14.6	13.5	16.0
	2825																		
707-2A	2816	4.00	2.88	5.06	21.83	18.09	24.25	5.25	4.19	9.42	28.81	24.62	31.54	4.71	3.62	5.50	14.9	13.5	15.7
	2825																		
708-2A	2816	2.66	1.25	4.07	19.73	15.84	23.13	5.10	2.13	13.32	25.23	22.13	28.98	5.75	4.48	6.50	15.1	14.1	15.9
	2825																		
709-2A	2816	3.00	1.48	4.75	20.22	17.30	23.52	6.74	1.90	12.82	27.34	25.00	30.71	4.70	4.32	5.08	14.1	13.1	14.9
	2825																		
710-2A	2816	2.99	1.82	5.67	21.45	16.32	27.73	4.40	0.07	10.74	26.62	23.09	30.58	5.17	4.82	5.46	14.7	13.0	15.6
	2825																		
711-2A	2816	4.47	2.36	5.62	22.39	19.12	26.06	4.48	1.59	7.31	29.37	25.55	33.86	5.04	4.26	6.43	14.3	9.0	15.9
	2825																		
712-2A	2816	4.01	2.66	5.34	22.99	18.35	26.08	6.19	1.61	12.12	30.11	28.08	31.74	4.35	3.89	4.98	15.0	13.0	16.3
	2825																		
713-2A	2816	5.05	3.61	6.93	21.50	18.50	24.61	6.10	3.91	9.17	28.88	25.97	30.99	4.58	4.12	4.86	14.9	13.9	16.5
	2825																		
714-2A	2816	0.41	3.53	8.80	20.01	13.87	24.97	4.82	-0.54	14.35	29.91	23.17	36.16	4.37	0.44	6.24	15.2	14.1	16.5
	2825																		
714-2B	2816	9.58	8.74	10.41	21.08	20.23	22.74	1.11	0.21	1.73	32.59	31.20	34.78	3.78	3.78	3.78	15.3	14.2	17.0
	2825																		
715-2A	2816	3.67	1.94	4.82	20.05	16.54	26.00	6.52	4.26	9.12	27.06	24.62	28.89	4.93	4.11	5.86	15.0	14.2	15.7
	2825																		
716-2A	2816	2.88	0.20	6.29	20.59	16.48	23.96	8.40	5.19	12.43	27.28	25.25	29.41	4.66	3.98	5.57	14.4	13.0	15.5
	2825																		
717-2A	2816	4.52	2.03	7.82	21.24	12.83	26.40	6.73	3.03	16.38	28.80	22.31	33.57	4.39	2.92	6.48	14.8	13.1	22.4
	2825																		
718-2A	2816	5.37	2.97	8.16	18.76	14.24	23.88	8.43	3.10	8.95	27.34	24.98	29.10	4.70	3.69	5.54	14.3	13.1	15.3
	2825																		

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PERCENT SULFITE OXIDATION AVG	MIN	MAX	STOICHIOMETRIC RATIO AVG	MIN	MAX	PERCENT IONIC IMBALANCE AVG	MIN	MAX
623-2A	2825									
624-2A	2816 2825	14.4	-2.5	25.6	1.04	1.02	1.07	1.6	-6.7	8.2
625-2A	2816 2825	15.5	5.6	33.7	1.15	1.07	1.37	1.7	-7.7	8.1
701-2A	2816 2825	11.9	1.1	46.4	1.21	1.13	1.42	2.7	-1.4	7.5
702-2A	2816 2825	6.3	0.1	19.6	1.16	1.07	1.28	0.5	-8.5	7.2
703-2A	2816 2825	6.3	0.5	16.5	1.12	1.05	1.18	0.8	-4.2	5.0
704-2A	2816 2825	14.3	0.8	65.4	1.11	1.02	1.70	3.2	-7.9	8.4
705-2A	2816 2825	12.8	1.8	43.7	1.10	1.03	1.21	2.9	-8.1	7.9
706-2A	2816 2825	18.9	3.3	36.3	1.13	1.04	1.35	-0.5	-7.6	8.4
707-2A	2816 2825	16.2	12.8	28.6	1.23	1.16	1.31	3.1	-0.9	6.8
708-2A	2816 2825	16.8	7.5	40.1	1.16	1.08	1.23	4.0	-1.2	8.2
709-2A	2816 2825	20.6	6.2	35.1	1.18	1.08	1.32	4.0	0.2	7.1
710-2A	2816 2825	13.9	0.2	34.5	1.18	1.10	1.40	3.5	-7.6	8.3
711-2A	2816 2825	13.9	4.8	22.9	1.25	1.13	1.33	3.1	-1.5	7.9
712-2A	2816 2825	17.7	4.8	34.6	1.21	1.13	1.31	1.8	-3.4	8.3
713-2A	2816 2825	18.4	12.6	25.3	1.28	1.19	1.44	-2.3	-8.5	5.0
714-2A	2816 2825	15.1	-1.9	33.2	1.41	1.15	1.65	2.9	-4.5	7.4
714-2B	2816 2825	3.9	0.8	6.4	1.64	1.59	1.68	3.6	1.8	5.2
715-2A	2816 2825	20.7	13.2	29.1	1.22	1.09	1.30	1.0	-7.1	7.6
716-2A	2816 2825	24.5	16.0	34.3	1.16	1.01	1.41	-1.2	-8.5	7.0
717-2A	2816 2825	20.4	8.5	45.2	1.25	1.10	1.55	-1.0	-7.8	8.5
718-2A	2816 2825	21.6	11.1	31.8	1.34	1.16	1.53	-1.7	-8.3	8.1

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

RUN NO.	ANALYTICAL POINT	CO2			SO2			SO3			CAO			ACID INSOLUBLES WT % IN SLURRY			SOLIDS WT % IN SLURRY		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
719-2A	2816	2.68	0.55	4.96	20.85	18.13	24.25	6.36	4.16	10.86	26.36	24.62	28.49	4.76	4.04	5.37	14.8	13.5	16.7
	2825																		
801-2A	2816	3.40	1.32	6.20	10.84	7.39	13.74	14.98	10.39	18.61	24.31	21.41	26.86	5.05	4.79	5.30	14.5	12.9	15.4
	2825																		
801-2B	2816	3.42	2.03	4.60	7.44	4.82	11.94	15.32	11.72	19.09	21.88	19.47	24.69	5.06	4.77	5.35	14.7	12.3	16.0
	2825																		
802-2A	2816	2.98	1.87	4.03	9.08	6.09	10.89	14.26	10.11	17.25	22.16	20.20	24.69	5.18	4.88	5.43	15.3	14.5	16.0
	2825																		
803-2A	2816	0.48	0.15	0.87	1.29	0.59	2.12	15.24	4.99	25.84	12.65	5.80	20.27	7.54	4.94	10.83	15.1	14.1	16.4
	2825																		
804-2A	2816	0.63	0.15	1.88	0.82	0.00	1.44	14.80	3.40	29.77	12.10	2.89	24.00	8.12	5.35	10.96	15.1	13.3	17.0
	2825																		
805-2A	2816	1.80	0.24	5.33	1.16	0.15	6.81	17.64	6.70	28.01	16.07	9.76	24.60	6.55	5.25	9.69	15.1	13.8	16.7
	2825																		
	2831	1.03	0.07	3.16	1.11	0.18	2.61	19.48	5.96	27.92	16.22	8.52	24.09				15.4	14.1	16.9
806-2A	2816	1.52	0.48	3.36	8.30	4.70	13.60	14.37	9.84	21.67	19.67	16.58	22.74	6.15	5.88	6.30	14.4	13.5	15.0
	2825																		
	2831	1.45	0.77	3.10	8.80	5.33	14.64	13.02	9.93	23.88	19.08	15.27	23.29				14.9	14.1	16.1
807-2A	2816	2.56	0.83	4.40	0.68	0.00	1.80	19.60	13.75	25.43	17.47	11.18	23.97	5.55	4.14	7.22	14.8	13.5	16.0
	2825																		
	2831	2.70	0.37	5.48	0.69	0.00	2.17	20.31	15.52	26.95	18.34	12.60	24.90	5.05	5.05	5.05	15.5	13.0	17.1
808-2A	2816	5.72	3.37	7.46	1.07	0.17	2.53	16.46	6.73	28.25	19.78	13.11	30.10	5.00	3.86	5.57	14.9	12.6	16.1
	2825																		
	2831	5.73	4.12	7.29	1.16	0.16	3.13	14.67	3.63	24.88	18.58	11.76	24.85				17.1	13.9	47.7
809-2A	2816	8.61	7.53	10.23	0.78	0.26	2.35	23.54	15.41	35.18	29.03	24.17	35.52	5.21	4.14	5.86	15.6	14.0	17.1
	2825																		
	2831	8.26	6.82	11.00	0.94	0.17	3.42	23.41	10.88	37.92	28.40	23.13	36.23				16.4	14.7	18.0
810-2A	2816	4.25	0.99	6.75	0.68	0.09	2.89	25.54	22.07	32.94	23.45	18.37	30.36	3.91	3.12	4.76	15.1	13.7	17.5
	2825																		
	2831	4.21	1.15	8.30	0.72	0.09	2.89	24.04	15.87	32.13	22.57	13.37	29.73				16.1	14.3	19.0
811-2A	2816	7.75	4.18	9.82	0.84	0.32	2.17	18.93	12.96	26.57	23.49	19.82	25.55	4.33	3.21	5.21	14.8	13.5	15.9
	2825																		
	2831	8.73	5.94	12.58	0.98	0.33	2.17	14.65	2.58	21.59	22.59	17.54	24.91	5.06	3.07	8.01	14.7	13.0	16.2
812-2A	2816	7.45	5.06	12.21	1.13	0.31	2.15	16.32	6.35	20.89	22.29	15.04	27.14	5.63	3.67	9.07	14.4	10.9	16.7
	2825																		
	2831	7.41	4.45	12.32	1.29	0.56	2.43	15.78	4.99	22.74	21.58	13.53	27.84	5.62	3.11	7.88	14.7	10.8	16.3
813-2A	2816	1.54	0.93	3.22	0.94	0.17	1.80	22.11	4.52	27.68	17.81	5.52	20.70	6.23	4.07	11.47	14.9	14.1	15.5
	2825																		
	2831	0.88	0.33	1.29	0.91	0.18	1.86	20.71	5.21	27.65	16.16	5.75	21.68	6.64	3.94	11.00	15.0	14.0	16.0
814-2A	2816	1.92	0.73	4.16	7.31	2.62	11.03	14.97	10.53	17.95	18.54	15.67	20.36	6.49	5.73	7.84	14.7	14.3	15.0
	2825																		
	2831	1.85	0.74	3.90	7.28	4.91	9.08	15.84	11.75	20.54	19.31	16.51	21.61	6.32	5.19	7.68	15.0	13.3	15.7
815-2A	2816	3.86	2.53	5.79	14.82	11.93	17.39	12.09	7.79	15.75	26.02	23.79	27.72	4.84	4.07	5.31	14.9	14.2	15.6

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

		PERCENT SULFITE OXIDATION			STOICHIOMETRIC RATIO			PERCENT IONIC IMBALANCE		
RUN NO.	ANALYTICAL POINT	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
719-2A	2816	19.6	13.4	30.8	1.15	1.03	1.33	0.8	-5.1	7.5
	2825									
801-2A	2816	52.5	37.7	65.5	1.22	1.08	1.42	-0.1	-5.3	7.8
	2825									
801-2B	2816	62.8	48.1	72.3	1.27	1.13	1.47	1.2	-3.9	6.7
	2825									
802-2A	2816	55.6	42.9	68.7	1.22	1.12	1.30	1.9	-3.6	7.5
	2825									
803-2A	2816	88.7	65.6	96.6	1.06	1.01	1.21	1.7	-8.4	8.3
	2825									
804-2A	2816	93.0	79.5	100.0	1.07	1.03	1.15	1.5	-7.7	8.4
	2825									
805-2A	2816	92.0	69.3	98.8	1.23	1.02	2.20	2.5	-5.3	7.1
	2825									
	2831	91.9	74.6	98.9	1.12	1.01	1.63	1.7	-6.2	8.0
806-2A	2816	58.0	36.7	78.7	1.12	1.03	1.26	2.0	-8.2	5.8
	2825									
	2831	54.3	35.2	78.2	1.12	1.05	1.27	2.3	-7.1	7.5
807-2A	2816	96.1	91.3	100.0	1.23	1.09	1.37	-0.7	-8.2	4.6
	2825									
	2831	96.1	89.6	100.0	1.24	1.04	1.51	0.3	-7.0	6.4
808-2A	2816	91.8	81.9	99.1	1.63	1.37	2.26	0.3	-8.1	7.5
	2825									
	2831	88.6	48.1	99.1	1.74	1.42	2.76		-7.4	8.4
809-2A	2816	96.1	86.8	98.5	1.68	1.44	2.08	3.1	-3.7	8.5
	2825									
	2831	95.3	82.2	99.1	1.70	1.34	2.72	2.6	-4.0	8.1
810-2A	2816	96.9	90.1	99.5	1.31	1.06	1.49	-2.1	-7.8	6.5
	2825									
	2831	96.5	89.9	99.6	1.31	1.09	1.66	-1.2	-8.0	7.2
811-2A	2816	94.4	82.7	98.3	1.74	1.28	2.08	-1.8	-8.0	7.4
	2825									
	2831	90.1	76.0	98.0	2.59	1.52	7.52	1.7	-7.8	8.2
812-2A	2816	92.2	85.1	97.5	1.89	1.44	3.32	1.4	-8.1	8.4
	2825									
	2831	89.9	80.6	96.7	1.99	1.35	3.70	-0.5	-8.2	7.5
813-2A	2816	94.3	85.2	99.1	1.15	1.06	1.60	-2.9	-7.8	8.4
	2825									
	2831	93.4	82.6	99.2	1.10	1.02	1.36	-1.8	-7.1	6.2
814-2A	2816	62.9	48.7	84.6	1.15	1.05	1.36	-4.3	-7.4	-0.9
	2825									
	2831	63.5	55.8	74.7	1.15	1.05	1.37	-2.7	-7.1	2.4
815-2A	2816	39.3	29.8	49.8	1.23	1.14	1.35	-1.3	-7.6	4.5

RUN SUMMARY - SOLIDS ANALYTICAL DATA

CONCENTRATIONS IN SOLIDS, WT %

RUN NO.	ANALYTICAL POINT	CO2			SO2			SO3			CAO			ACID INSOLUBLES WT % IN SLURRY			SOLIDS WT % IN SLURRY		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
815-2A	2825																		
816-2A	2816	4.70	3.74	5.69	10.22	8.44	13.04	13.59	9.80	15.44	24.24	23.36	25.74	5.19	4.80	6.07	15.2	13.8	16.0
	2825																		
	2832	4.36	3.30	5.31	11.15	8.86	13.41	13.09	9.82	16.36	24.09	23.50	25.29	5.57	4.79	6.80	16.3	14.8	17.9
817-2A	2816	2.93	1.87	3.74	1.18	0.28	3.44	22.31	13.25	24.83	20.14	13.64	22.59	5.25	3.97	8.08	14.6	13.2	17.7
	2825																		
	2832	2.64	1.37	3.52	1.25	0.36	3.11	24.26	20.26	27.56	21.15	19.44	23.71	5.35	4.33	7.29	14.8	12.6	17.1
818-2A	2816	4.30	3.19	5.58	7.21	4.70	9.23	17.91	14.39	21.04	25.17	23.41	26.44	4.82	3.87	6.11	14.9	14.1	16.3
	2825																		
	2832	4.58	3.80	5.95	7.54	4.34	10.13	17.69	13.68	22.47	25.60	23.50	27.77	4.61	3.71	5.91	15.0	13.5	16.2
818-2B	2816	4.26	2.19	5.87	19.80	17.01	22.86	7.71	5.35	10.87	28.42	25.53	31.34	4.16	3.57	4.68	14.3	13.4	15.3
	2825																		
819-2A	2816	3.92	1.48	6.57	1.17	0.18	2.76	21.72	17.71	26.51	21.20	15.67	26.43	4.70	2.99	6.53	12.9	10.7	14.7
	2825																		
820-2A	2816	6.96	3.45	9.79	1.30	0.36	2.17	18.44	10.11	22.36	23.34	13.20	26.86	4.77	2.97	7.02	13.8	11.7	15.6
	2825																		
821-2A	2816	3.66	1.00	9.60	0.86	0.20	2.10	20.89	10.48	27.23	19.53	14.50	24.20	6.76	5.20	11.50	14.9	13.4	16.1
	2825																		

RUN SUMMARY - SOLIDS ANALYTICAL DATA (CONTINUED)

RUN NO.	ANALYTICAL POINT	PERCENT SULFITE OXIDATION			STOICHIOMETRIC RATIO			PERCENT IONIC IMBALANCE		
		AVG	MIN	MAX	AVG	MIN	MAX	AVG	MIN	MAX
815-2A	2825									
816-2A	2816	51.6	37.6	58.9	1.33	1.25	1.42	-0.9	-6.0	3.6
	2825									
	2832	48.3	36.9	59.6	1.30	1.22	1.38	-1.6	-4.8	3.6
817-2A	2816	93.9	82.1	98.6	1.24	1.14	1.42	-1.3	-6.7	3.0
	2825									
	2832	93.9	84.1	98.3	1.19	1.08	1.24	-1.5	-7.9	5.9
818-2A	2816	66.5	55.5	78.2	1.29	1.22	1.38	3.4	0.1	6.5
	2825									
	2832	65.2	53.8	80.6	1.31	1.24	1.40	3.0	-0.9	7.4
818-2B	2816	23.8	15.8	32.9	1.24	1.11	1.34	0.8	-2.8	4.5
	2825									
819-2A	2816	93.7	86.1	99.1	1.31	1.11	1.56	-0.2	-8.5	5.5
	2825									
820-2A	2816	91.7	84.6	98.0	1.64	1.32	1.97	1.9	-3.5	7.3
	2825									
821-2A	2816	94.8	83.1	98.9	1.35	1.06	2.28	-2.6	-8.3	6.4
	2825									